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Child Behavior, Animal Behavior, and Comparative Psychology

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INTEGRATION AND MOTIVATION OF BEHAVIOR AS PROBLEMS OF GROWTH*

From the Wistar Institute of Anatomy and Biology

G E. Coghill

This paper is presented as a summary of my work on the correlation of structure and function in the development of behavior and as an application of my results to psycho-physiological problems of integration and individuation. The treatment must necessarily be brief and possibly unsatisfactory to critical students, but an exhaustive presentation of the subject cannot be presented at this time. The following treatment, it is hoped, will at least make my biological approach to psychological problems intelligible.

My neurological investigations began in 1898, and dealt specifically with a variety of the genus *Amblystoma Cope,* which genus, with the exception of temporary diversions to nearly related forms (*Diemyctylus, Triton,* or *Triturus*), has been the subject of my studies to the present time My earlier research dealt with purely neurological problems, particularly the analysis of the cranial nerves into their functional divisions according to the conception of functional components which had developed in America, chiefly through the work of Henry Fairfield Osborn, Oliver S Strong, C Judson Herrick, and John B Johnston It was some six or seven years later that I conceived the idea of studying the development of behavior in these urodele amphibians with a view to determining whether or not the development of behavior could be correlated in a definite way with the structural development of the nervous system.

When I began these correlated anatomical and physiological studies it was not known whether the behavior of an animal comes to be what it is by chance or by an orderly development as in the case of its structure. There were on record numerous studies of the movements of embryos, chief among which were the monumental investigations by Preyer. Preyer had, in fact, described important features of the movements of amphibians in the egg, but he did not disclose

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any orderly sequence of these movements culminating in a definitive behavior pattern such, for example, as locomotion Preyer studied extensively, also, other types of vertebrates, especially the chick, but here again he concerned himself particularly with the classification of movements (*Allokinetische*· Passive, Irritative, Reflex, *Autokinetische*: Impulsive, Instinctive, *Vorgestellte*) without explaining their orderly genesis. My first step, therefore, in the correlation of nervous structure and function in the development of behavior was of necessity to determine whether or not the behavior developed in an orderly manner in the animal which I proposed to study anatomically

My first preliminary studies of the development of behavior were in 1906 upon embryos of *Rana* and *Amblystoma,* but my first published report was in 1907 upon *Diemyctylus torosus* Eschscholtz In this animal I found that the first reaction to light touch with a hair, whether on the side of the head or on the trunk or tail, was a bending of the most anterior part of the trunk to one side As the embryo grew older this lateral flexure progressed caudad till the whole trunk was involved in the movement. Eventually this unilateral flexure became extreme and resulted in a close coil of the trunk. During this period it was observed that every movement began in the anterior end of the axial musculature and progressed caudad. This cephalocaudal progression in later development, it was discovered, effects locomotion, for after the coil reaction has become perfected the flexure which would ordinarily result in a coil is reversed before it has been completed, and there result two flexures in opposite direction, the one following the other tailward through the axial musculature. When the animal reached the degree of development which enabled it to perform these cephalocaudal progressing flexures in series, it could swim. Aquatic locomotion, accordingly, was found to be acquired through an orderly development of function in the axial musculature. This fact had not been observed by Preyer or earlier investigators.

Another important fact that had been overlooked by other investigators is that the movements that lead up to swimming in the salamander are total reactions During this period there are no perceptible contractions of isolated segments or groups of segments of the axial musculature excepting at its anterior end, in which case they are simply the beginning of total reactions which ordinarily extend tailward throughout the axial musculature but which stop short of full performance—they are abbreviated total reactions.

At the time when *Amblystoma* begins to swim there are no mobile appendages The external gills are clearly defined as nobs of epithetical tissue, and the fore limb is even less developed than the gills, while the hind limb is not yet perceptible. As development proceeds the gills first become motile, then the fore limbs, finally the hind limbs, and as each pair of these appendages becomes motile they move only with contractions of the axial musculature For a relatively long period they are integral parts of a total pattern of action which includes the axial and appendicular musculature, but, of themselves, they have no power of response to tactile stimulation upon them. Eventually, however, independence of action is acquired by the appendages, and this independence of action of the several pairs of appendages, gills, fore limbs and hind limbs, is acquired by them in the same order in which they acquired the ability to act as a part of the total pattern, and their independent movement is the same in configuration as the earlier movement which was a part of the total pattern The appendage thus acquires a degree of individuality of its own. For this reason, I call the process, by which this individuality of the appendage is acquired, individuation. Total integration, accordingly, is the primary condition of the behavior of *Amblystoma.* Local reactions or reflexes are of secondary origin, and arise within the total pattern They do not arise outside the total pattern and become added to it by accretion. Neither do local reactions or reflexes form the total pattern by accretion with each other They emerge within a primarily integrated pattern, and become coordinated with each other through their primary integration with the total pattern

This solidarity of organization of the reflex within the total pattern of action is seen in the earliest local reflex action of the fore limb in response to light touch on the limb This earliest reflex can be elicited only when the animal is forced into a definite and specific posture, which is at this time a total reaction of axial and appendicular musculature, before the reflex action of the limb alone can be elicited in the normal posture If at this time the animal is brought into an approximately supine position with the body slightly twisted upon its longitudinal axis, one leg is elevated and the other depressed. While in this position the elevated limb will respond to tactile stimulation with a sharp movement of elevation. The earliest reflex action of the limb is thus liberated from the pattern of total integration by conditions prevailing in the total pattern itself.

That the allied reflexes acquire their mutual coördination with each other through the total pattern is shown in certain early responses of the external gills and the fore limbs. Before the limb has acquired local reflex action, a touch on the limb causes either total action of the animal or a local reflex of the gill, and, under *these conditions of normal* posture, the earliest reflex action of the limb occurs only in combination with action of the gills. Later the limb acquires independence from the action of the gills, and the pure reflex of the limb becomes established. In this case, the condition of alliance of two potentially independent reflexes is primary, and their separateness is secondary. Just as the gills acquired relative independence of the overt total pattern of action, so the fore leg acquires relative independence from a pattern of integration which includes gills and leg The same principle is observed also in the development of rotation of the hind leg, which does not acquire the ability to abduct and rotate separately, and then combine these actions into abduction-rotation. The earliest rotation of the leg, on the contrary, occurs as a phase of abduction. It occurs only at extreme abduction, and in this manner effects the plantigrade position of the foot before the foot is an actual factor in locomotion through contact with a surface.

Terrestrial locomotion, like the aquatic, is also a total action pattern in *Amblystoma* The walking gait involves action of the trunk, fore limbs and hind limbs. The action of the trunk in walking is a slow swimming movement which, as in aquatic locomotion, progresses from the head tailward. With the beginning of the movement in walking, if the head moves to the right, the right fore limb adducts (moves backward) and the left fore limb abducts (moves forward) As the fore limbs move in this manner the flexure progresses tailward and, as it reaches the level of the hind limbs, the right hind limb abducts *and* the left hind limb adducts. This integration of trunk and limbs in the walking gait is established before the hind limbs touch the surface on which the animal rests during the process, while they still act as paddles without flexion at knee or ankle, before they rotate to a plantigrade position, and before they have any power of local reflex action in response to light touch In the beginning of the walking gait, therefore, the limbs function wholly as integral parts of a total pattern of action without any intervention of local reflexes. Local reflexes of the limbs appear later, as the limbs become a factor in orientation of the animal with reference to a surface

The reaction of the fore limb to postural adjustment of the animal as a whole has already been mentioned in relation to the earliest reflex action of the fore limb In this case, before the fore legs have any power of local reflex action, the right leg elevates and the left leg depresses (moves ventrad) as the body rotates upward on the right side. The same reaction occurs in the hind legs upon rotation of the body before they have power of reflex action. The primary action of the limbs, accordingly, in orientation of the animal in space is a component of a total reaction. In orientation of the animal with reference to a surface, on the other hand, reflex action of the limbs participates

In *Amblystoma,* so long as the animal is aquatic, orientation with reference to a surface is a minor factor, and local reflexes of the limbs are proportionately of little consequence in behavior, but as the animal becomes terrestrial in its habits these reflexes become of much greater consequence Similarly, in higher vertebrates, which support themselves on surfaces wholly upon their limbs, these reflexes acquire still greater importance and a higher degree of individuation. In posture and locomotion, therefore, two factors are concerned· the total action pattern, which has to do with orientation in space in the definition of the gait, and the partial patterns or reflexes, which have to do preeminently with orientation in relation to surfaces But the local reflex components in these postural functions arise genetically within the total pattern of action, and in normal behavior act under its domination, just as the earliest reflex of the fore limb is dominated or conditioned by a postural total reaction which involves the whole animal.

The same principle of total action is followed in the earliest postures or acts which give evidence of attention. This form of behavior can be elicited by moving a small object through the animal's field of vision As the object passes from directly in front of the animal to its right, for example, the eyes rotate accordingly and the head follows the movement of the object by flexure of the trunk to the right, and, in cooordination with this movement of the axial muscles, the right fore leg adducts (moves backward) and the right hind leg abducts (or in the earliest phase of the reaction both hind legs may abduct simultaneously). Although the hind legs participate in this reaction, it occurs a relatively long time before they can respond discretely to local stimulation either by light touch, pressure, or forced manipulation. To any form of stimulation of the hind leg at this time the reaction is swimming; although at times the animal will lie quietly while the leg is being stimulated, so that capability of local reflex action can be thoroughly tested The act of visually regarding an object is, therefore, a total reaction Although it involves some parts which at the time can perform local reflexes it involves others that cannot The latter have no independence of action; the former under some conditions have it in a relative degree only, for they are quite as subservient to the organization of the total pattern in the act of regarding an object as are the parts that have no capability of reflex action. Regarding an object visually cannot in this case conform to the conception of chain reflexes. It is primarily and absolutely an act of the organism as a unit.

In the further performance of this act of attention, after the object has been followed into the limits of the field of vision, the animal may pause as if regarding the object intently, and then take a step or two towards it, or it may jump after it as in capturing its prey. This complete act involves, first, movement of the eyes and anterior portion of the axial musculature and then expansion of the field of perfectly integrated action through the fore limbs, the trunk, the hind limbs and tail. This expansion of perfectly integrated action, without the intervention of local reflexes, culminates in an adaptive posture with reference to the object in the field of vision, and finally the postural tonicity is released, probably by inhibition, into adaptive action (capturing food) The posture is the physiological equivalent of anticipation and attention.

This relation of posture to adaptive patterns of action is seen also in the development of swimming and walking As described above, the embryo of *Amblystoma* passes through a period in its development when it curls its body into a tight coil by means of a unilateral flexure progressing from the head tailward. This coiled position of the body is frequently held for many seconds, and may, therefore, be regarded as postural in nature, but a sudden release of the postural tonus on one side is continued into a flexure to the opposite side; while both these processes, the release of the primary flexure and the bending into the secondary or reversed flexure, progress caudad Posture in this case seems to be converted into locomotor action through inhibition. The special mechanism that brings this transition about will be described later on.

Locomotor action of the limbs, also, arises in *Amblystoma* in the same way. In the earliest use of its fore limbs for locomotion the animal extends both limbs simultaneously and then, by slowly adducting them simultaneously, it falls forward and thus gains a position slightly in advance of its original position. A little later in development, it raises its head and fore part of the trunk to an elevated position as before, but, instead of falling forward, it turns the head, for example, to the right and abducts the left fore limb In this act the right fore limb is drawn into an adducted position. This is the form of the earliest step, and when this position is taken it is held for some time as a fixed posture. It may occur many times before one of these attitudes or postures is released and succeeded immediately by a reversal of the performance so that one step follows another.

In the case of the hind limbs, also, before they begin to move alternately in coordination with the fore limbs in walking, both are abducted simultaneously when the animal starts to walk with the fore limbs Slightly later than this, when the animal acts as though it were starting out to walk, it assumes the walking posture with the fore limbs and flexes the body laterally to the level of the hind limbs. At this juncture the hind limb on the concave side abducts, and the other hind limb adducts This position of the body and limbs may be held for a relatively long time. This posture may be assumed many times before the animal actually begins to walk with the hind limbs, and when it does so, the postural position is released from the head tailward and the flexure of the body reversed In this reversal of body movement, the flexure of the body is accompanied by the coordinated action of the limbs which constitutes walking, as described above. Accordingly, the initiation of swimming, walking, and the act of feeding is effected by a release of a posture which expresses the basic integration of the respective acts.

It is suggested that this release of a postural pattern into an action pattern is brought about through inhibition of the initial tonic muscular contraction, which maintains the posture, in favor of the action of the antagonist musculature. And the action pattern, as already explained, is a total pattern. Its inhibition, then, must be effected by a pattern of total, as opposed to local, inhibition. The evidence of a total pattern of inhibition appears, also, in the individuation of local reflexes. For a period just preceding the appearance of the local reflex of the fore leg, for example, a touch on the potential reflexogenous zone not only fails to excite action of any kind, but, following the application of the stimulus upon the leg, the animal may be pushed about the dish by pressure upon the zone in which earlier a light touch excited violent action. But immediately after this, while the animal is under inhibition induced by light touch on the potential reflexogenous zone, a light touch on any other part of the body excites quick action. Then, following this period when touch on the potential reflexogenous zone inhibited total action, a touch in the same region excites a local reflex of the leg without perceptible action of the trunk. This same phenomenon appears in relation to the individuation of reflexes of the external gills and of the hind legs. Furthermore, as the time approaches for the animal to attack an object in the field of vision, as in capturing food, but before it does so, the animal may be pushed about the dish by pressure of the object so presented against the region about the mouth, whereas a light touch on any other part of the body at this time excites total action. The important consideration in all these cases of inhibition is that the pushing of the animal about the dish by pressure on the potential reflexogenous zone must stimulate many parts of the body, both exteroceptively and proprioceptively. The inhibitory effect, therefore, must be total as opposed to local in its scope. The local reflex, then, makes its appearance in a field of general inhibition.

In the performance of particular acts of the salamander there is a very intimate involvement with their development. It has been noted above that flexure of the trunk occurs first in the anterior region, and, as the animal grows older, the flexure involves more and more of the axial musculature. Genetically, then, contraction of the axial musculature develops from the head tailward. Physiologically, a particular contraction arises in the same manner Swimming is accomplished through cephalocaudal contraction of the axial musculature. The particular act of swimming, accordingly, is a telescoping, recapitulating, or syncopating of the development of the act. This holds also for walking, which, as described above, is at the outset a total action of the axial and appendicular musculature, proceeding from the head tailward. The act begins with a cephalocaudal flexure of the trunk according to the order of genetic development of the movement, and involves the appendages in the order according to which their movement developed genetically. The various organismic elements involved in the act of capturing prey, also, take part in that act according to the temporal order in which they acquired their function genetically For an understanding of the nature and components of a particular behavior pattern, therefore, the genesis of the pattern in time, in terms of the individual's life and development, must be taken into account

In the above sketch of the development of behavior in the salamander, the genesis of all the acts that are basic to the survival of the individual has been traced, namely, aquatic locomotion, terrestrial locomotion, capturing and swallowing food, and local reactions to stimuli in definitive reflexogenous zones With these necessary acts acquired, it remains only for the individual to adapt itself to its environment in the use of these functions as life proceeds The question now arises whether or not the animal uses the same method in adapting its acts to its environment as it used in acquiring those acts. The particular acts are acquired by the expansion of a primarily integrated total pattern of action and the individuation of partial patterns of action within the total pattern Can adaptation of behavior to the requirements of the individual, or learning in the broadest sense, be brought about by this method?

One factor of adaptation in behavior has already been mentioned, namely, alliance of reflexes As explained, two reflex performances which in later life may act either independently of each other or in alliance with each other are allied before they can be performed independently Their independence of each other is acquired by individuation within a larger pattern which includes them both. This situation is the same as the coordination of all four limbs in walking the fore limbs and hind limbs are coordinated with each other because they are integral parts of a primarily integrated whole. Any independent action of a limb in adaptation to a particular situation is therefore acquired by individuation within a larger integrated pattern

The conditioning of reflexes, also, involves the same principles as are observed in the development of unconditioned reflexes; only the process is much more rapid in conditioning than it is in genesis In case of the unconditioned reflex the process is regarded as development, while in the conditioned reflex it is thought of as physiological; but such a distinction between developmental and physiological processes in the nervous system is purely hypothetical. My work has demonstrated that some neurones grow while they function as conductors, and that their growth is correlated with the development of their function. Under such conditions function and growth are inseparable When neural growth of this order ceases in the course of the life of the individual is not known. Its continuance would not necessitate increase in the mass of the nervous system, for differentiation of tissue may occur with decrease in its mass, as, for example, in the metamorphosis of amphibians and insects. On *a priori* grounds, therefore, the hypothesis that there is growth going on in the nervous system so long as the individual can adapt its behavior to changes in its environment is not untenable. The conditioning of reflexes may, then, be regarded as involving not only a physiological factor but also a factor of growth.

It is known that in the beginning of experimental conditioning both the motor and the sensory factors are relatively very diffuse and general in their scope On the sensory side there occurs with the advance of conditioning a progressive reduction in the extent of the reflexogenous zone or the range of the impinging stimuli (sound) Simultaneously there is also a progressive reduction or delimiting of the motor response Accordingly, both the receptor and the effector functions that are involved in conditioning arise through individuation within larger fields of action; and this is exactly what occurs in the development of unconditioned reflexes Minkowski, for example, has pointed out that in the early stages in the development of the plantar reflex in the human fetus the typical response could be excited by a touch on the dorsum of the foot as well as on the plantar surface, and that plantar stimulation excited extensive action of all the toes, the foot, and even the leg It appears, accordingly, that conditioned and unconditioned reflexes differ in regard to their genesis only in the rate at which they are acquired

Chain reflexes may also be interpreted upon the same principles. Jacques Loeb used the act of capturing food by the frog as the type of chain reflexes. According to Loeb, the retinal image of an insect excited the frog to jump after the insect and then the insect within the mouth excited swallowing But when the development of the neural mechanism that is concerned in the act of capturing and swallowing food is understood, the act is recognized not as a series of independent reflexes, the one exciting the next in the series, but as a unitary act from first to last. Visually regarding an object has been explained above as being necessarily a total pattern of action, and this act is the primary component of the feeding reaction Without doubt, the presence of food in the mouth modifies the act of swallowing, but according to the nature of the neural mechanism involved, the frog does not wait till the food is in its mouth before it begins the act of swallowing The structure of the mechanism shows that the retinal image must arouse to action the entire sensory-motor apparatus involved in capturing the prey and swallowing it. The act is an integrated whole in which the successive elements emerge in appropriate order to consummate the act If, perchance, the leap for the prey be unsuccessful and the oral stimulation wanting, there is sound anatomical evidence that the reaction would not stop short at that point but that the act of swallowing would be carried out, at least incipiently, in the absence of the morsel of food

The chain reflex of Loeb has been accepted by many students of behavior as the explanation of instincts· instinctive performances are regarded as extensive series of chain reflexes initiated by a particular stimulus from the environment The validity of this interpretation cannot be discussed at length here, but it must be obvious that the interpretation just given of the chain reflex itself as a total pattern of action is destructive to the idea that an instinctive act is simply a series of independent reflexes Instinctive behavior involves the whole organism. Within the total pattern of action as it extends in time there emerge successive components which may superficially resemble reflexes but which are integral parts of a primarily integrated space-time pattern, just as the individual limbs of the salamander are coordinated with one another in walking by virtue of the fact that each one is an integral part of a primarily integrated whole. But at any point in the progress of the instinctive pattern in time there may occur reinforcement, interference, or modification by local reflex action, just as the anti-gravity postural reflexes emerge in the total pattern of the walking gait, which is, itself, a total pattern of action, that is to say, not formed by accretion or coördination of primarily independent local reflex patterns.

In short, a satisfactory understanding of behavior requires that it be perceived as a unitary pattern which unfolds in time as well as in space, and that particular performances are an expression of their genetic development In other terms, behavior is a space-time pattern, and the concept of unity of pattern must be regarded as temporal as well as spatial This principle may be observed in the development of the nervous system as well as in the development of behavior

There is in the salamander a nervous mechanism that integrates all somatic movements into a unitary pattern of action. It is composed of longitudinal neurones which lie next to the floor plate on either side of the central nervous system These neurones conduct tailward, and give off collaterals which go out of the spinal cord as ventral root-fibers and innervate the axial muscles. The primary motor neurone is, accordingly, an integrating neurone. In the early stages of development the organization of the sensory system and the floor plate, through which stimuli must pass to reach the motor system, is such that stimuli from all parts of the body must enter the motor system at its anterior end During this period, owing to this arrangement, all contractions of the axial musculature begin in the anterior part and progress tailward. As a result of this organization of the nervous system the axial musculature is integrated, and swimming is made possible.

But, as stated above, the act of swimming is initiated by the release of a strong postural tonus which expresses itself in a tight coiling of the trunk, this release being followed by a flexure in the reverse direction. At the time when such a release of postural tonus begins to occur, very fine collaterals are found on the motor neurones within the spinal cord in the anterior region These collaterals go to the cells of the floor plate which, in turn, go into the motor tract of the opposite side These collaterals are regarded as having inhibitory action upon the axial musculature of one side while that of the other contracts, according to the principle of inhibition of the antagonist It is this mechanism that was mentioned above in regard to the relation of posture to locomotion through inhibition.

The mechanism which integrates the axial musculature integrates, also, the appendicular musculature with the axial This is accomplished by means of branches from some of those fibers which innervate the myotomes These branches go to the musculature of the limbs, and are the first motor fibers to reach the limbs. The earliest movements of the limbs are, by reason of this anatomical arrangement, necessarily integrated with movements of the trunk.

This mechanism of total integration in the young salamander becomes the fasciculus longitudinalis medialis of the adult. This tract extends in the salamander from its nucleus in or near the boundary between the diencephalon and mesencephalon through the medulla oblongata and spinal cord, and is the primary neural organ of locomotion. In higher forms, such as mammals, it is large in the brain but diminishes in size as it passes downward and soon disappears in the fasciculus proprius ventralis of the spinal cord. Its spinal portion maintains its identity in those forms which use the trunk and tail directly in locomotion; but in those forms which use the appendages directly in locomotion and their trunk as primarily a postural anchorage for the limbs in this function, the fasciculus longitudinalis medialis loses its identity more or less in the spinal cord, where the fasciculus proprius ventralis, composed of relatively short neurones, serves posture more immediately than locomotion proper

But in the higher vertebrates the fasciculus longitudinalis medialis is the first longitudinal conducting system to make its appearance in the embryo. He says it is found in a human embryo of 6 9 mm in length. In point of time, therefore, it is the primary motor mechanism of the human nervous system The primary relation of this tract in mammals is with the nuclei of the eye-muscle nerves, which control all movements of the eyes, including their conjugate deflection. Now, these movements of the eyes, although involved in postural reactions, are primarily allied with movements of the head that are involved in locomotion. Accordingly, the fasciculus longitudinalis medialis in higher vertebrates integrates the movements of the eyes with those of the head (neck) in posture and locomotion, just as in the salamander it integrates the limbs with the trunk. It consolidates the parts with which it is related into a unitary system.

In a recently published work C Judson Herrick shows that the nucleus interpeduncularis of *Necturus* is a part of the mechanism of total integration, for axones arising from some of its cells enter the tract of this mechanism. This nucleus, it is important to note, is an end-station for the earliest tracts to appear in the forebrain: the nervous terminalis, the habenulo-peduncular tract, the mamillo-peduncular tract, and the olfacto-peduncular tract. Accordingly, through these conduction paths the earliest nervous function of the forebrain must act, not on local reflex mechanisms, but upon the mechanism of total integration. This condition demonstrates in a broad way the expansion of the mechanism of total integration into the higher segments of the brain, and, for this reason, gives anatomical grounds for the view that the functions of the higher centers of the brain develop according to the same principles that are observed in the development of the functions of the spinal cord: namely, by the expansion of a primarily integrated total pattern and individuation of partial patterns within it. These principles we found, also, in the development of conditioning of behavior, which is regarded as a function of the higher brain centers.

To this point the discussion has related wholly to integration It remains now to consider the relation of the growth of the nervous system to the motivation of behavior.

The observations by H. C. Tracy on the early behavior of the toadfish furnish the key to the problem of motivation Tracy found that the embryos of this fish carry on definite more or less rhythmic integrated muscular contractions for a considerable period before it is possible to demonstrate sensory functions, either exteroceptive or proprioceptive The embryos could be forcibly bent and otherwise abused without arousing any motor functions, but when they were allowed to lie quietly in the water they would at comparatively regular intervals execute contractions of the axial musculature. These actions Tracy called "endogenous" rather than "spontaneous," because he found that their rate was accelerated by increasing the concentration of carbon dioxide in the water. He concluded, accordingly, that as ordinarily executed these movements were excited normally by the accumulation of carbon dioxide in the blood or tissues as a phase of respiration. There is, therefore, in the early behavior of this animal, a "drive" to action like the "hunger drive" and the "sex drive" in higher animals, but it begins to function in the toadfish without the intervention of a sensory component of the nervous system. Furthermore, after a sensory component is developed, and after it can be demonstrated as participating in the general behavior of the toadfish, the endogeneous "drive" contributes the tempo of performance. Also, other fishes, which have a more rapid tempo of endogenous action in the pre-sensory stage than does the embryo of the toadfish, differ from the toadfish in the same way in their tempo of action as adults. The pre-sensory endogenous drive of the embryo, therefore, goes over into adult life and contributes basic characteristics of the animal's behavior.

In relation to this endogenous drive, Angulo y Gonzalez has established a most important principle. He has demonstrated that, under progressive asphyxiation of the fetus of the rat by ligation of the umbilical cord, movements are made in reverse order to that in which they appear genetically in normal development. This means that the sensitivity of the nerve cells of this animal to endogenous stimulation is correlated with their age or stage of development—the youngest or least mature cells being the most sensitive; and the older the cell the less sensitive it is to endogenous stimulation. The application of this principle to my observations on the development of the nervous system of *Amblystoma* as correlated with the development of behavior has important bearing on the problem of motivation of behavior.

The primary stimulus-response mechanism of *Amblystoma* is relatively simple. The afferent neurones conduct the impulse from the receptors to neurones of the second order, which in the spinal cord are located in the floor plate. Through the latter cells the impulse is carried to the motor cells of the opposite side. While this primary stimulus-response mechanism is the only functional part of the central nervous system, other neuro-blasts are differentiating out of the neuroepithelium outside this mechanism, and growing by means of their axones into it. In other words, new neurones develop outside the stimulus-response mechanism and beyond the range of physiological stimulation from the receptors. Furthermore, their axones grow into the mechanism of total integration so that if stimulated endogenously (they cannot be stimulated exogenously by reason of their isolation from the sensory system) they would excite the animal to total activity. And such activity characterizes the "drive" of the psychologists.

The degree to which nervous organization in the brain develops beyond the field of exogenous stimulation in *Amblystoma* is illustrated in the diencephalon and mesencephalon, in which the major conduction paths can be recognized before there can be demonstrated any afferent fibers into these parts of the brain from the metencephalon, from the telencephalon, or from the retina. The degree of development of these neurones, judged by the structure of the spinal neurones which are known to be conductors, indicates that they have acquired nervous function. Now, since they are younger and less mature than the neurones of the stimulus-response mechanism, they must be, according to the results of Angulo y Gonzalez, more sensitive than the latter to endogenous stimulation; and since there are efferent neurones from the mesencephalon into the mechanism of total integration, endogenous stimulation would arouse the animal to total action. But this mechanism of the diencephalon and mesencephalon, which is in its early condition subject only to endogenous stimulation, is soon invaded by afferent neurones from the retina, telencephalon, and lower segments of the brain, and so becomes incorporated into the stimulus-response mechanism.

Nevertheless the field of endogenous stimulation is not lost by this incorporation of the early centers and tracts of the diencephalon and mesencephalon into the stimulus-response mechanism, for while this incorporation is taking place higher centers are still developing in the forebrain beyond the confines of the stimulus-response mechanism, and becoming subject in the same manner to endogenous stimulation. And so it is, upon this hypothesis, that so long as the brain is growing by the maturation of neurones, there is in it a nervous field that under endogenous stimulation can function in the intrinsic motivation of behavior. Such motivation I regard as basic to instinctive behavior and, therefore, an important factor in all those psychopathological processes in which instinct plays a part.

In relation to psychopathology another principle of development must also be taken into account, namely, the conflict that prevails from the first between the mechanism of total integration and the mechanisms of partial patterns The latter, as already explained, arise within the mechanism of the total pattern and give rise to partial reactions (reflexes) as opposed to the total pattern of action The mechanism of the total pattern tends to maintain complete integrity of behavior; the mechanisms of partial patterns tend to destroy this integrity In the growth and function of these systems there is necessarily a perpetual conflict The simplest expression of this conflict occurs in the spinal cord in relation to reflexes of the limbs In order that such local actions can serve the purpose of the organism as a whole, they must be under the control of the mechanism of total integration. The higher and more complicated expression of this conflict concerns the integrity of the personality Here it is chiefly the cerebral cortex that is the seat of conflict between the partial and total patterns of integration The various components of the personality, according to this hypothesis, just as local spinal reflexes, develop by individuation within the mechanism of total integration, and their normal function depends upon their subordination to that mechanism. But this relation may be destroyed either by a weakening of the mechanism of total integration or by hypertrophy of mechanisms of partial patterns. The integrity of the personality, therefore, upon this biologic basis, must be regarded essentially as a problem of growth within the nervous system, and the normally functioning nervous system must be regarded as a growing organ

In brief, the results of my study of the growth of the nervous system in relation to the development of behavior support the hypothesis that learning is essentially growth, and that mental hygiene is fundamentally a problem of growth This interpretation receives support also from the work of numerous investigators whose work cannot be mentioned within the limitations of this article

Fallsington, Pennsylvania

THE EFFECT OF CASTRATION AT VARIOUS AGES UPON THE LEARNING ABILITY OF MALE ALBINO RATS II RELEARNING AFTER AN INTERVAL OF ONE YEAR[1]

From the Psychology Laboratory of Stanford University

CALVIN P STONE AND W. D COMMINS

In a preceding paper by Commins (1), it was shown that castration of male albino rats at the ages of 20, 50, 90, 130, and 170 days had no deleterious effects on their learning of three mazes and a discrimination task that were given when they were between six and 7 1/3 months of age Fifty days after completing this series of tests the males, now nine months of age, were subjected to relearning tests on the same instruments, which lasted 20 days. All groups relearned their tasks readily and no significant differences were found between the castrated and the control groups.

One year (a few days more or less) after completing the first relearning tests, all members of the control and the castrated groups that were in good health were brought together again for the same series of tests Now they were 20 months old, which is the approximate mid-point of the rat's life-span (6). In this, the final relearning tests, the authors were on the lookout for long-time, cumulative effects of castration on the learning performance of rats. It seemed possible that cumulative effects of castration, although not detectable in the first relearning tests, might manifest themselves after the peak of physical vigor had been passed

I. ANIMALS RETESTED

During the one-year interval between relearning tests the males were released in two large rooms, each with floor dimensions of 180 square feet, where they had freedom to run about and to climb from the floor to shelves in the room, but where there was no op-

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portunity for recapitulating their maze or discrimination habits Many of the animals that completed the original experiments had died before the present relearning tests were begun Others, because of pulmonary disorders, emaciation, or general motor decrepitude were eliminated by the experimenters. Only those males that were sleek and free from obvious respiratory disorders were considered suitable for a rigorous series of tests such as the present ones involved While examining animals and accepting or rejecting them for the present experiments the experimenter paid no attention to the earmarks by means of which the groups to which they belonged might be ascertained. Therefore, prejudice on the part of the experimenter could have played no rôle whatever in determining which animals would undergo the second relearning tests.

Because of reduced numbers in the several groups, which would make difficult any adequate statistical analysis of results, we have pooled (1) the data for the 20- and 50-day groups (they being sexually immature when castrated), (2) the data for the 90-, 130- and 170-day groups (they being sexually mature at the time of castration), and (3) the data for the normal and pseudo-castrated controls. Although this method of grouping is somewhat arbitrary, it has the advantage of affording us an opportunity to compare those castrated prior to sexual maturity with those castrated thereafter, as well as an opportunity to compare the castrated animals with the non-castrated controls Hereafter, the males castrated when 20 and 50 days of age will be called the premature castrates (*Pr-C*); the 90-, 130-, and 170-day castrates will be called the post-mature castrates (*Po-C*), and the non-castrated and pseudo-castrated groups will be called the controls (*Ctrs*) In Table 1 are given the original numbers of animals in each of the newly constituted groups, the number that finished the first relearning series, and the number

TABLE 1

NUMBERS OF RATS IN EACH GROUP

Group	Original N	First relearning N	Second relearning N
Pr-C	73	66	20
Po-C	112	111	34
Ctrs	72	68	30

completing the present relearning tests. A relatively small number of cases that began the second relearning series but became ill before completing it have been discarded.

Forty-four per cent of the controls that finished the first relearning series completed the present tests, whereas only 30 and 31 per cent of the premature and the post-mature castrates, respectively, completed these same tests. Since the husbandry of all animals was the same during the retention interval, so far as is known, one may legitimately suspect that the greater mortality among the castrates was in some way due to the fact that they had suffered the loss of testes.

But a positive conclusion to this effect will not be drawn by us because we did not give sufficient attention to the individuals of each group to warrant the assumption that all essential external environmental factors actually were the same for the normal and castrated males. Obviously, when animals are at liberty in a large cage they may exercise a considerable degree of choice in determining their own immediate environments Certainly, therefore, more crucial data than those of the present experiment should be provided before one would wish to draw the highly significant conclusion that longevity in intact male rats significantly exceeds that of castrated rats. Nevertheless, there are sufficient grounds for suspecting that this is a correct conclusion to warrant further investigation of this point.

II. RELEARNING TESTS

Before beginning the present relearning tests, the males were assembled in laboratory cages (18x18x8 inches) and their food ration gradually reduced over a period of two weeks so that each male lost approximately 20 per cent of his weight at the beginning. The lightest and heaviest rats weighed, respectively, 275 and 496 grams, and the average weight was 355 grams. All were relatively fat, hence even after a loss of from 50 to 100 grams (the two extremes) they were still in excellent condition. During the entire relearning period their weights were kept at approximately 80 per cent of their colony-room weights

The order of the relearning tests was the same as that of the original series, but fewer trials were given in the relearning series (cf 1, p. 33). The rats received two trials a day, or 30 trials, on the multiple-*T* maze, and simultaneously with these, two trials per day on the light-discrimination box Then came two trials a day, for ten days, on the elevated-1 maze, and lastly there were two trials a day, for five days, on the elevated-2 maze No preliminary training was given the animals. All were very tame and, of course, one year before had mastered these same problems, hence it was thought best to begin the regular trials without giving preliminary training on the straightaway (cf Commins 1, p. 34). As in all of the original experiments, some individuals of each group were in training at all times, lest adventitious factors might affect animals of one group but not a similar number of animals of the others.

III. Similarity of Performance in the Original Tests

Although the significant differences between results from the original groups of animals, as reported by Commins (1) were rare and distributed unsystematically, it seemed advisable to inquire as to whether there might be significant differences between the *original* error and time scores of the newly constituted groups Sometimes a redistribution of individuals so concentrates extreme cases in small groups, such as we have to deal with in the present instance, that significant differences appear. If there are differences of this kind we should be aware of them at the outset because there would be a strong tendency for them to reappear in the relearning series, since original learning and relearning scores of animals usually have a high positive relationship (3, 4)

Table 2 presents the statistical constants for the original groups As can be seen by inspecting the critical ratios, there is but one clearly significant difference in the table The *Pr-C* group is significantly poorer than either of the others on the elevated-2 maze Their mean error score on the elevated-1 maze is also poorer than that of either of the other groups, but the difference is of less certain statistical significance. Neither group is consistently better or poorer in all of the tests than either of the other groups, and this, we believe, is the essential point to hold in mind Retracing errors were so few in numbers that no consideration to them has been given

Table 3 presents the comparable time scores for the newly constituted groups There are no significant differences on any of the tests and no group is consistently better or worse than another.

TABLE 2

MEANS OF THE TOTAL NUMBERS OF ERRORS FROM THE FOUR LEARNING SITUATIONS IN THE ORIGINAL TESTS

Also, sigmas of the distributions, standard deviations of the means, and critical ratios

Group	Mean	S.D.	σ_M	Po-C	Ctrs
	Errors on the multiple-T maze			Critical ratios	
Pr-C	72.6	28.7	6.4	615	667
Po-C	78.2	37.4	6.4		000
Ctrs	78.2	30.1	5.5		
	Errors on the elevated 1 maze				
Pr-C	40.7	17.8	3.8	2.732	2.000
Po-C	29.5	9.2	1.6		581
Ctrs	31.3	14.7	2.7		
	Errors on elevated-2 maze			Critical ratios	
Pr-C	21.7	12.2	2.5	1.000	3.571
Po-C	18.8	8.9	1.5		3.250
Ctrs	12.3	6.7	1.3		
	Errors on light-discrimination box				
Pr-C	28.0	8.1	1.7	2.150	1.773
Po-C	23.7	6.8	1.1		222
Ctrs	24.1	7.4	1.4		

TABLE 3

MEANS OF THE TOTAL TIMES SPENT BY EACH GROUP ON THE MAZES, SIGMAS OF THE DISTRIBUTIONS, STANDARD DEVIATION OF THE MEANS, AND CRITICAL RATIOS

Group	Mean	S.D.	σ_M	Po-C	Ctrs
	Time (seconds) on multiple-T maze			Critical ratios	
Pr-C	744.3	290.9	65.0	1.132	934
Po-C	861.8	472.3	81.0		282
Ctrs	832.0	371.6	67.8		
	Time (seconds) on elevated-1 maze			Critical ratios	
Pr-C	874.0	316.2	67.4	2.558	1.799
Po-C	689.8	150.5	25.4		1.142
Ctrs	738.2	186.2	34.0		
	Time (seconds) on elevated-2 maze			Critical ratios	
Pr-C	452.5	206.0	43.0	695	719
Po-C	419.4	120.2	20.3		.091
Ctrs	416.4	140.0	26.0		

IV SECOND RELEARNING SCORES (After one-year interval)

Table 4 gives the statistical constants that we have used in comparing the error scores of the three groups in the present relearning series. Most of the differences in the means are small and are in the

TABLE 4

MEANS OF THE TOTAL NUMBERS OF ERRORS FROM THE FOUR RELEARNING SITUATIONS

Sigmas of the distributions, standard deviations of the means, and critical ratios of the differences between means

Group	Mean	S D	σ_M	Po-C	Ctrs
	Errors on the multiple-T maze			Critical ratios	
Pr-C	65.8	25.7	5.7	171	986
Po-C	64.6	23.2	4.0		1.407
Ctrs	72.9	24.3	4.4		
	Errors on elevated-1 maze			Critical ratios	
Pr-C	36.6	13.9	3.0	1.486	118
Po-C	31.1	13.2	2.2		312
Ctrs	32.1	12.8	2.3		
	Errors on elevated-2 maze			Critical ratios	
Pr-C	17.4	7.4	1.5	1.570	1.740
Po-C	14.5	5.5	.9		.256
Ctrs	14.2	5.2	1.0		
	Errors on light-discrimination box			Critical ratios	
Pr-C	18.7	7.8	1.6	3.106	.660
Po-C	13.9	5.6	.9		2.329
Ctrs	17.4	6.5	1.2		

same direction as the small differences appearing in the original learning series. As can be seen by inspecting the critical ratios, the controls are not consistently better or worse than either of the other groups on all of the tests. In but one test, light discrimination, are there differences between means that either are statistically significant or closely approach significance. In this test, the mean error score of the post-mature castrates (*Po-C*) is lower than those of the premature castrates (*Pr-C*) and the controls (*Ctrs*). Since the means of the controls and the premature castrates are so similar on this test, however, it appears doubtful whether we should attach any great significance to this isolated instance of superiority. If this position is taken, we may conclude from the data of Table 4 that the present tests of relearning reveal no beneficial or deleterious effects of castration, even when the experimental animals have been deprived of their gonads for periods ranging from 13 to 19 months.

Table 5 presents the comparable mean time scores for the three groups on the three mazes. In this connection, it may be appropriate to say that we do not attach any significance to time scores as measures of learning, but report them merely as measures of locomotion

TABLE 5

MEANS OF THE TOTAL TIMES SPENT BY EACH GROUP IN RELEARNING ON THE THREE MAZES

Sigmas of the distributions, standard deviations of the means, and critical ratios

Group	Mean	S D	σ_M	Po-C	Ctrs
	Time (seconds) on multiple-T maze			Critical ratios	
Pr-C	587.3	215.4	48.2	.514	.434
Po-C	559.2	151.2	25.9		810
Ctrs	609.7	310.5	56.7		
	Time (seconds) on elevated-1 maze			Critical ratios	
Pr-C	867.4	293.5	62.6	1.812	.532
Po-C	738.6	199.4	33.7		.617
Ctrs	804.3	552.7	100.9		
	Time (seconds) on elevated-2 maze			Critical ratios	
Pr-C	519.9	180.0	37.5	1.962	1.402
Po-C	436.1	120.8	20.4		.367
Ctrs	450.2	178.6	32.6		

under conditions in which there is a high degree of hunger motivation. On the elevated maze there is, of course, some call for agility because of the narrowness of the treadways.

As shown by the critical ratios of Table 5, no group was significantly better than another as to mean time scores. In this respect the data are consistent with observations of the experimenters who were unable to determine by any animal's performance whether it was a castrated or an intact male.

V. GENERAL SUMMARY AND INTERPRETATION OF OUR FINDINGS

The groups participating in the original learning and relearning tests were in the prime of life when tested. Some of them had been castrated prior to sexual maturity and others after this phase of sexual development had been reached. Although the numbers of cases in each of the original groups was greatly reduced prior to the second relearning tests, all groups were represented in the final tests. By throwing together all of the premature castrates, all of the post-mature castrates, and all of the non-castrated animals we have three groups of sufficient size to warrant comparisons of the mean time and error scores. At the beginning of the second relearning tests, the surviving males had reached, or possibly passed, the mid-point of the normal life-span for rats that are reared and maintained under good conditions of husbandry (6).

The final conclusions from the three learning and relearning situations may be briefly stated Castration at various ages from infancy to adulthood had no beneficial or deleterious effects on the mastery and remastery of a light-discrimination problem and three different maze patterns. Also, there was no evidence of long-time, cumulative effects of castration on relearning scores for these same instruments

Since the data from reliable mazes are usually positively correlated (2, 5) there is no reason for believing that results differing from the foregoing would have been obtained had mazes of still different patterns been used The light-discrimination apparatus seems to measure functions that differ from those measured by the maze (2), and, so far as known to the present authors, there are no published data which indicate the relationship between various discrimination tasks. That being the case, no generalization from the light discrimination data to other discrimination tasks is warranted at the present time

Finally, we may say, further studies of the effects of castration should be made by using insight and reasoning problems, which probably do not depend upon the same intellectual functions in the rat as those tested in the present experiments Although we have no positive evidence that insight and reasoning problems would yield data differing in any essential trend from those of the present investigation, it is best for the present to regard these as unexplored provinces for future investigations.

VI CONCLUSIONS

1. Male albino rats 20 months of age and castrated at the ages of 20, 50, 90, 130, and 170 days were found to equal intact males in relearning a light-discrimination problem and three mazes of diverse patterns which originally had been mastered approximately one year earlier

2. The castrated males did not appear to differ from the normal males in agility or in rate of running in these learning situations

3 These results, when added to those of the preceding study (1), indicate that the testicular secretion is unnecessary for the maintenance of such intellectual traits or abilities in rats as are measured by the light-discrimination problem and by mazes of diverse types and patterns.

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VISUAL DISCRIMINATION IN THE CAT III THE RELATIVE EFFECT OF PAIRED AND UNPAIRED STIMULI IN THE DISCRIMINATIVE BEHAVIOR OF THE CAT*[1]

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I. INTRODUCTION

From the standpoint of physical measurement the environment in which animals live must be considered as undergoing constant change, a continued alteration which comes about either as a result of the movement of the animal itself, or because of external disturbances independent of the action of the organism Only in the most general sense can it be said that the environment to which living mammals are subjected after birth is constant and uniform. Yet, in this changing environment, the typical adjustment of all animals to standard space commonly exhibits unmistakable constancy and consistency. Because of the limitations placed upon the number of responses at the organism's disposal, it is necessary that these constant, adaptive responses be made to partly novel situations or complexes of stimuli which are quite different in certain objectively measurable characteristics

The question has been raised from many standpoints in psychology as to the basic factors operating to produce this constancy or transfer of response Besides somewhat explanatory naming by terms such as "abstraction" (Révész, 17), "conception" (Fields, 1), "generalization" (Pavlov, 16, Tellier, 24), "induction" (Skinner, 19), "transfer of training" (Thorndike, 25), "transposition" (Kohler, 10), "functional equivalence of stimuli" (Lashley, 13, Kluver, 8), and "constancy of form, color, etc." (Koffka, 9), many supplementary theories have been offered to account for this required characteristic of behavior In studies of transfer of training identity of cer-

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tain autonomous elements in the stimulus situation, or in the neural process resulting from stimulation, has been offered as a theory to explain the results (Thorndike, 25). *In addition, the theories of* surrogate processes (Hunter, 6) have been employed to account for transfer of response in complex situations, as, for example, those involved in conditioning experiments (Guthrie, 3), form discrimination (Neet, 15) and various other conditions (Holt, as quoted by Latif, 14) It is assumed by these writers that a sort of symbolic mechanism, or an identity of response-induced stimulation acts to bring about constancy of response in situations possessing different stimulus characteristics.

In general, however, studies on the discriminative behavior of different animals have given rise to a class of theoretical formulations somewhat different from the hypotheses just mentioned These studies have involved mainly the training of animals in response to two stimuli of differential characters and thereafter modifying the differential stimuli themselves or secondary factors in the situation as a whole The results have shown, for the most part, that the differential stimuli, or, for that matter, almost any aspect of the situation, can be changed without bringing about variations in the consistency of the response. This technique is exemplified in experiments on brightness discrimination, in which it has been shown that two pairs of stimuli of different absolute value but of roughly comparable relative value will elicit, in some cases at least, consistent differential responses after training has been carried out with only one pair. Similar results have been secured in studies of form, size, and many other types of discrimination in various kinds of animals.

The results of experiments of this sort have been given wide interpretation by such writers as Köhler (11), Koffka (9), Lashley (12, 13), Kluver (8), and others. A basic assumption involved in their interpretation of these experiments is that in infra-human animals such as chimpanzees and chickens a "natural" or basic form of reaction, independent of past training, can be secured. Since, in the main, it has been observed that transfer of response is, at least in part, correlated with changes in the relative value of brightness or size stimuli, it has been further directly concluded that reaction to relational or configural factors is natural or basic.

Lashley's (12) formulation of this theory, for example, may be summarized by his own statements on the subject. On the basis of experiments with differential pattern stimuli, he states, "The common elements in transfer are not common neurones but common ratios of excitation in different neuronic systems. . . The stimulus to any reaction above the level of the spinal reflex involves, not the excitation of certain definite sensory cells, but the excitation of cells in certain ratios, and the response may be given to the ratio, even though the particular cells involved have not previously been excited in the same way during the formation of the habitual reaction" (pp 476-477).

The theory of response based upon relational factors has been given a new impetus by the experiments and theories of Kluver (8) Extensive experiments with visual, auditory, and weight discrimination were made by this investigator in which the differential character, as well as non-differential secondary factors in the situations, were changed after the establishment of a response to a particular stimulus situation The outcome of the experiments showed that with these various types of discriminative behavior, rather marked changes could be made in the relative values of the stimuli, in their absolute value, or in secondary non-differential aspects, without modifying the consistency of the established response Furthermore, the dependence of the responses upon a certain limit of change in secondary non-differential factors was demonstrated.

Starting out with knowledge of the fact that transfer of response takes place from one stimulus situation to other different objective circumstances, Kluver (8) assumes that there must be some recognizable identity in the different situations. He maintains that this identity is not to be found in the physically measurable characteristics of the situation, and that, therefore, the animal does not "respond" to the objective conditions. Since the term "stimulus" is regarded as the factor which is identical in all of the situations and the factor responded to, redefinition of this term is carried out along speculative lines. Since Kluver takes for granted that there is no possibility that any of the physical properties in the situation are identical, he argues that such identity is to be found in the "phenomenal experience" of the animal This domain is conceived as possessed of "relational properties" apparently naturally organized, that are always the same when the same response takes place. In consequence of previous assumptions and definitions these properties are said to constitute the "stimuli" or the factors directly related to the same consistent response This assumption is tersely stated by Kluver himself, as follows. "It must be assumed that the constancy of response is dependent upon the existence of such stimulus properties as makes heterogeneous stimulus constellations 'identifiable' " (p 365).

It is asserted that the means by which the nature of such phenomenal properties can be ascertained is by inference from the experimenter's own experiences and from a knowledge of the animal's behavior According to Kluver (8), there is no evidence "incompatible with the hypothesis that the organism in question is reacting to something which in my experience appears phenomenally as 'red,' 'attractive,' 'aggressive,' etc." (p 7) The fact that different phenomenal properties may be present in two different situations, as far as the experimenter can judge, and yet not give rise to the same response by the animal, demands and is given further explanation. Thus, as additional assumption is made that it is not only single properties, but "properties effective in conjunction with other properties," "various kinds of 'phenomenal togetherness,' " or "interdependence of aspects" which are the ultimate sensory determinants of behavior (p 366).

Another series of experiments related to the general problem of transfer of response in discriminative behavior has involved the presentation of stimuli so that there is an unequal number of positive and negative choices for the animal. Kluver (8) has also advanced interpretations as to the basis of transfer of response in such "unpaired" situations along with his theories as to why transfer takes place when one stimulus is paired with another. In his experiments he required one monkey, which had been used extensively in previous experiments with paired stimuli in visual discrimination, to select between one black circle, as positive, and three black squares, as negative The animal gave significantly consistent responses during the first presentation of thirty trials, as did also an additional animal, highly trained in paired stimulus situations, when one black square was positive and three black circles were negative Both animals responded consistently thereafter in a "reversed" situation, i e, one in which a square was positive where three had previously been negative, and three circles negative, where one had previously been positive Both animals also discriminated consistently in situations presenting brightness and apparent color differences in the three-to-one relation However, in additional tests, involving reversed situations of the sort described above, neither animal gave consistent responses to the single stimulus, as it had learned to do in the primary training, but responded only to a stimulus which was positive in the preceding test series An additional subject, untrained in discrimination problems, did not respond consistently at first but required approximately fifty trials before it could select between one black square, as positive, and three white squares, as negative No reversals of the stimuli were presented, but the animal did thereafter discriminate between squares of different brightness and color, as well as different weights, when these stimuli were given in the three-to-one relation. All three animals discriminated at once between paired stimuli similar to those used in the primary training

Other investigators have reported limited results bearing on the nature of response transfer in complex situations consisting of unpaired stimuli. Hadley (4), in experiments with size and pattern discrimination with the guinea-pig, found that animals learning three choices would transfer to situations involving two choices. Gayton (2), however, found that rats, trained in brightness and size discrimination under conditions of two possible choices, at first responded indiscriminately when three choices were possible Robinson (18), using the monkey, failed to find immediate transfer in a reversed situation, as did Kluver (8), when one black disc was negative and two gray squares positive in the modified conditions In the primary habit, the animal responded to the black disc as positive, and to the gray squares as negative In fact, the ability of the animal to respond selectively as the two situations were reversed arose gradually in the same way as did the primary habit., Robinson used the same method as that employed by Kluver.

Explanation of certain phenomena related to his own experiments with unpaired stimuli has been offered by Kluver (8) In his study, he describes paired stimuli as "equilibrated" and unpaired stimuli as "non-equilibrated" or "strata" stimuli. He attributes the somewhat more rapid rate of initial learning in unpaired situations, as based upon the study of a single untrained animal, to the fact that these conditions are distinguished by possessing "figure-ground" character, whereas paired stimuli are said to lack this feature The reason why animals transfer readily from one unpaired situation to another of the same general sort is because the stimuli are of the same "strata." In summarizing his experiments with the unpaired or "non-equilibrated" stimuli, the statement is presented that "it is impossible to consider the difference between 'equilibrated' and 'non-equilibrated' stimuli as nothing but a difference in conditions with regard to punishment and reward" (p. 318). It was also held that the learning of paired stimuli had no influence upon the performance in unpaired situations.

No attempt was made to resolve the inconsistency in the assumptions just reviewed and the fact that paired and unpaired stimuli were equivalent in giving rise to constant discriminative responses, after training had been carried out with either one or the other, which fact, in accordance with the primary assumption made at the beginning of the study, would seem to necessitate the conclusion that similar "phenomenal" properties would be involved in the two conditions.

II. PROBLEMS

Because of certain unsolved questions raised by the studies just summarized, the present experiments were undertaken in an attempt to ascertain (1) the relative rate of establishment of a discriminative response in the cat to visual patterns in paired and unpaired stimulus situations, (2) the nature of transfer of response between paired and unpaired stimuli after training has been carried out under both conditions, (3) the types of visual patterns which function as similar in a four-stimulus situation, after training has been carried out with one particular arrangement, and (4) whether or not transfer of response can be demonstrated between situations having no differential relative values in common, viz., between situations involving visual pattern differences and those presenting auditory stimulation.

III. METHODS AND PROCEDURE

Complex stimulus conditions for the study of paired and unpaired stimuli are obtained by arranging two or more units of a lever discrimination apparatus in the manner shown in Figure 1 and diagrammatically represented in Figure 2. This apparatus, which has been described elsewhere by the writer (Smith, 20, 23), consists of a box, 29.2 cm long, 27.9 cm. wide, and 33 cm. high, painted flat black. A door, a wooden frame 1.9 cm. wide, swings inward by

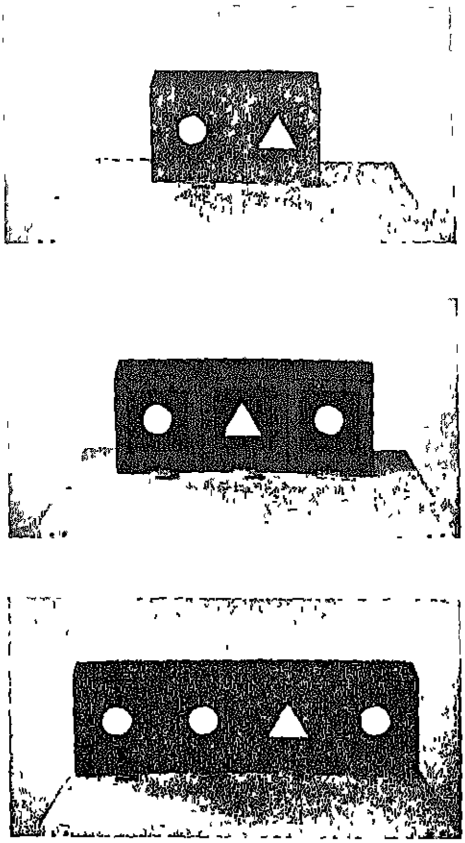

FIGURE 1
The Arrangement of the Stimulus Boxes for the Study of the Discrimination of Paired and Unpaired Stimuli

means of springs attached to its rear side. Its front side is fitted with grooves into which frosted glass or cards bearing various types of visual stimuli may be easily inserted or removed. Inside the box, directly below the level of the lower part of the door, is a shelf for a food plate. The door of the box is held tightly closed by a small spring latch, to which is attached a brass lever, that extends 10.5 cm outward from the box and terminates in a brass plate of a size

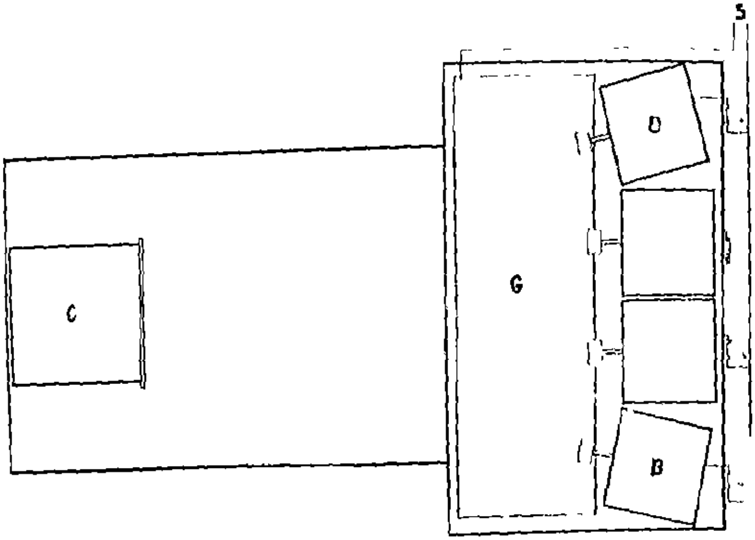

FIGURE 2

B, stimulus boxes; C, restraining cage, G, galvanized iron flooring; S, source of electrical shock.

ample to accommodate the paw of the animal. The cat secures the food (small pieces of salmon) by depressing the lever and then thrusting its head and forebody through the aperture of the opened door The door may be locked by a rotary latch, and punishment may be administered by electrical current led through the lever and suitable conducting grills placed in front of the apparatus.

The boxes are placed along the rear side of a table, 137 cm by 92 cm top surface, and illuminated by flood lights suspended from the ceiling directly above the restraining cage A second table, 152 cm by 106 cm top surface, is placed lengthwise and centered perpendicularly along the side of the table containing the boxes Both tables are 60 cm. high

A restraining cage for the subject, 46 cm. square, containing a sliding door on its front side, is located at the opposite end of the runway table The door of the cage is controlled by a string led through pulleys to the experimenter's position behind a screen which is placed 120 cm from the sides of the table During experimentation the animal's movements are observed from behind th screen by means of a mirror suspended from the rear wall near the restraining cage. Motion pictures of the behavior were sometimes made during and after training from a position at the back of the experimental room.

The animal is first accustomed to the experimental situation by preliminary feeding in one unit of the apparatus Training in depressing the lever is begun when the animal learns to leave the restraining cage and go directly to the opened box in order to obtain food. If a particular subject is not active, it is held near the lever in front of the closed door of the box and its fore paw placed on the lever, causing the lever to be depressed and the door to open. This procedure is then repeated until the subject is capable of operating the lever itself. In general, no more than sixty trials are required before a response of this sort is thoroughly learned, many animals, especially aggressive cats, may learn the trick in as few as ten trials.

When the habit of manipulating the lever is thoroughly mastered, training with visual stimuli is begun by presenting two, three, or four boxes, depending upon the aspect of the problem to be investigated. Each individual animal is then given a series of twenty trials per day, the time of the experiments extending approximately from ten o'clock P M to one-thirty A M

After a discriminative response by the animal, the experimenter moved from behind the screen and returned the cat to the restraining cage. The tops of the boxes were then opened and fresh pieces of salmon placed on the glass plates behind the doors The food was handled with a pair of small tweezers in order that no odors would attach to the stimulus cards when they were inserted into or removed from the doors The appropriate change of stimuli was made by removing the exposed cards and shifting their relative positions After the change in the positions of the cards, the latches locking the doors containing negative figures were rotated, and electrical punishment, when in use, changed to the levers corresponding to the negative stimuli.

The order of alternation of the stimuli between the boxes was arranged with reference to a chance procedure, except in cases where persistent position habits were broken by presenting the positive stimulus a greater number of times in one or another of the boxes For situations involving paired stimuli, a first series of alternations was calculated in which there was a possibility of ten "rights" and ten "lefts." This gave an arrangement for ten trials which was thereafter modified in four different ways. The alternation of the stimuli in the unpaired situations was arranged in a similar manner, except that the shifts in relative position of the figures were made with reference to three or four possible positions.

Determinations of differential behavior by this method are validated by the procedure used and by means of check experiments made after any particular investigation. Extraneous cues are not obtainable from the experimenter, since the animal, from the moment of its release from the restraining cage to the moment of securing food, cannot see the experimenter, and itself performs all of the necessary operation of the apparatus. Cues from the manner of release from the restraining cage are held constant since the door is always raised to the same height and there held until the animal completes a response by inserting its head and fore body within the aperture of the discrimination apparatus.

The influence of olfactory cues is controlled by frequently replacing fresh cards for used ones, or by utilizing, in check experiments, different sets of stimulus cards consisting of a circle and triangle for each door The figures could thus be shifted in position independently of the particular cards upon which they were drawn. Odors from the food are held constant by always placing fresh pieces of salmon on the glass food-containers before each response.

The animal cannot respond on the basis of tactual cues and still discriminate. In making a response the cat touches only the lever of the apparatus, and if it comes into contact with the lever corresponding to a negative stimulus an error is recorded. Any differential influences from the electric shock may be ascertained by check experiments in which the shock is eliminated.

Additional factors, such as the method of handling the animal when returning it to the restraining cage, the manner of opening and closing the doors of the discrimination boxes, the order of alternation of the stimuli, etc., are controlled by uniform procedure In previous experiments (Smith, 21) it has been shown that, with the procedure here adopted, these factors are not operative in influencing the types of differential behavior which may be elicited by the present method

IV. RESULTS

1 *The Rate of Learning in Paired and Unpaired Stimulus Situations* Nine subjects (Laboratory Numbers 8, 9, 10, 11, 12, 13, 14, 15, and 16), which were maintained on a normal diet and under regular laboratory conditions, were divided into three different groups, of three animals each, for investigation In the first series of experiments discriminative responses to paired stimuli (one triangle and one circle of equal area) were established in three animals (Subjects 8, 9, and 10) Two animals of the second group (Subjects 11 and 12) learned an unpaired situation involving one triangle and two circles of equal area. The third animal of this group (Subject 13) responded positively to a white card and negatively to two black cards. The third group of animals (Subjects 14, 15, and 16) responded to one triangle, as positive, and to three circles, as negative In every case the figures were approximately 70 square cm in area.

The training of the third group of animals differed from that of the other two in that no electrical punishment was employed until a significant level of response (75 per cent response to the triangle in twenty trials) was exceeded. With the other two groups, the shock was introduced after one hundred trials had been given In the case of all three groups an error was recorded when the animal touched a lever corresponding to a circle.

The learning in situations of this sort may be evaluated on the basis of two arbitrary criteria, namely, (1) the number of separate trials required to reach a consistent level of response (a trial in this study being defined so as to include all of the responses made after the animal is released from the restraining cage and until it obtains food), and (2) the number of responses occurring to negative stimuli before differential behavior appears A comparison of the results with respect to these two criteria is summarized in Table 1, which presents the trial series in sets of 40 trials, the percentage of incorrect trials, and the number of responses to negative stimuli during the training The percentage of incorrect trials is given in the left part of the columns below the numbers designating each subject

Using a learning criterion of 90-per-cent-correct choices of the triangle in forty trials, a discrimination between the figures was established with fewer trials in the four-stimulus situation (200-320 trials) than in either the three- or two-stimulus situations. Animals

TABLE 1

The Trial Series, Percentage of Incorrect Trials, and Number of Responses to a Negative Stimulus (*N*) in Sets of Forty Trials

Situation	Two stimuli						Three stimuli						Four stimuli					
Subject	8		9		10		11		12		13		14		15		*16*	
Trial Series	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
0-40	75	30	60	24	58	23	70	44	75	56	90	52	73	102	68	148	78	118
40-80	75	30	73	29	70	28	73	53	78	57	80	74	65	56	75	108	85	104
80-120	70	28	58	23	55	22	63	26	80	61	73	51	60	41	60	51	78	108
120-160	48	-19	63	25	75	30	50	34	85	60	78	52	33	23	50	58	78	104
160-200	55	22	65	26	50	20	*13	6	73	50	60	45	18	15	13	7	78	94
200-240	25	10	48	19	15	6	15		65	51	75	40	15	7	* 5	4	65	74
240-280	15	6	45	18	38	15	13		57	52	75	61	*10	8	8		58	70
280-320	20	8	43	17	* 8	3	15		65	58	68	46	3				53	58
320-360	15	6	50	20	5		18		53	37	63	44					23	10
360-400	* 8	3	28	11			20		53	43	28	38					*13	8
400-440	10		23	9			13		60	46	20	23					15	
440-480			25	10			13		55	33	*18	7					13	
480-520			*10	4							15	6					20	
520-560			13															
560-600			10															
	400	161	520	235	320	147	200	163	480	604	480	539	280	252	240	376	400	748

*Criterion of learning fulfilled or approximated.

responding to paired stimuli, however, required fewer trials (320-520) than did those learning the unpaired stimuli consisting of one triangle and two circles In the latter case, not one of the three subjects (Subjects 11, 12, 13) reached the required criterion of learning, although two animals (Subjects 11 and 13) approximated this level of response within 200 and 520 trials respectively. Subject 12 gave differential responses only 45 per cent of the time after approximately 500 trials

The greater economy of trials in learning the four-stimulus situation, as compared to that in the two-stimulus situation, is greatly offset by the total number of negative responses made before the habit was mastered. With the four stimuli, 252, 276, and 748 responses to a circle were recorded for the respective subjects, whereas 152, 235, and 163 such responses were made by animals learning the paired stimuli Furthermore, a greater total number of negative responses than were required for mastery in the two-stimulus situation took place in the three-stimulus situation up to the time when the learning criterion was approximated When learning criteria of 66 6 per cent and 50 per cent are chosen for animals of the two unpaired groups (two times chance probability of 33 3 per cent and 25 per cent respectively), these comparisons, as well as those pointed out above, are not materially altered.

The results are definite on the point that no clear-cut differences exist for the cat in the mastery of paired and unpaired stimulus conditions involving differences in visual patterns. The learning records of the animals fail to disclose differences in behavior by means of which paired and unpaired stimulus situations may be said to be qualitatively distinguishable Whereas the latter may give somewhat more economical results in terms of number of trials, it is far less economical in regard to the number of negative responses necessary for the establishment of consistent predictable behavior The results here secured with paired stimuli are in agreement with data obtained by the writer in a previous study of pattern discrimination in the cat (Smith, 21)

2 *Transfer of Response between Paired and Unpaired Stimuli* A second series of experiments consisted in presenting a group of eight animals (Subjects 8, 9, 10, 11, 12, 13, 14, 15) a number of stimuli different from that upon which they had been trained Table 2 presents the percentage of correct trials for the eight animals dur-

TABLE 2

PERCENTAGE OF CORRECT TRIALS OCCURRING DURING RESPONSE TO DIFFERENT NUMBERS OF STIMULI*

Situation Subject		Four stimuli %	Three stimuli %	Two stimuli %
8	(Trained	50	70 (10 T)	90
9	on	70	90	90
10	2 boxes)	70	80 (10 T)	90
11	(Trained	90	85	95
12	on		45 (40 T)	73 (40 T)
13	3 boxes)	70	80	90
14	(Trained	95	95	100
15	on	95	90	95
16	4 boxes)			

**Each trial period consisted of 20 trials except where otherwise indicated*

ing the separate tests carried out. Reference to the table will show that animals trained in response to an unpaired situation gave similar responses, without additional practice, to other unpaired, as well as to paired situations. Moreover, the subjects which learned the paired situation responded differentially, without further training, to situations involving one triangle and two circles or one triangle and three circles Subject 12, which showed no clear indication of learning an unpaired situation consisting of three stimuli, gave differential responses when presented with a paired situation. In two additional test periods given this animal, the response to the unpaired situation improved and discrimination of paired stimuli exceeded 90-per-cent-correct response. None of the animals tested failed to show more than a chance level of response in any of the test situations, except Subject 16. The animals which learned the paired stimuli were somewhat inferior in transferring to the different conditions, as compared to the ability of animals which learned unpaired stimuli

The responses found could be secured independently of electrical punishment, if it had been used as supplementary to the initial training Subjects 8 and 11, trained with electrical punishment, were not shocked for a response to the circles during the test periods here summarized. In addition, consistent responses were maintained in the test situations by Subjects 9 and 10, even though the doors bearing the circles were unlocked and the electrical punishment discontinued All animals responded with chance accuracy or less when confronted with black cards inserted into the doors of the discrimination boxes.

3. *Transfer of Response in Situations Involving Different Visual Patterns* From a previous study (Smith, 22), it is known that after an animal has been trained in a situation involving paired figures, other figures of different differential and non-differential attributes (from the standpoint of the experimenter) may be presented without modifying the behavior For example, an animal trained in response to a circle and triangle of equal area will still discriminate when the relative and absolute size of the figures are changed, when the form of one of the figures is modified, or when the triangle is rotated 180 degrees Do the same phenomena of transfer hold true for an unpaired stimulus situation presenting pattern differences, and, if so, do the modified situations have to be of such nature as to maintain the imbalance character of the primary stimuli?

One animal (Subject 15) was used in the experiments, which involved changes in (1) the relative size of the figures, (2) the black-white relation between the figures and the cards, and (3) the form of the figures The arrangement of the four boxes during the experiment was the same as that used in the initial training of the animal

In Figure 3 are presented the training figures (Combination 1) and the different sets of test stimuli, numbered in the order in which they were introduced, as tests, into the experiment. The figures employed in the different test periods consisted of the following a standard-size triangle with the brightness relation between the figure and the card reversed, standard-size circles with the brightness relation between the figure and the card reversed, larger circles of 182 4 sq cm area, smaller circles 39 6 sq cm in area, a black square 412 9 sq. cm in area, a white square 412 9 sq cm in area, a black rectangle 5 08 cm by 15 2 cm, the horizontal arm of a swastika of 10 2 cm over-all dimensions and 2 54 cm arm width, a white cross of 10.2 cm arm length and 1 27 arm width, a black cross of 10 2 cm arm length and 2 54 cm arm width The arrangement of these figures, as they were presented as tests in the experiment, can be understood by reference to the accompanying figure.

Each test series consisted of three trials, given consecutively during two experimental periods, no retests with the training figures being presented as the experiment progressed. The subject received no punishment other than the failure to obtain food for response to one of the arbitrarily defined negative stimuli

The level of response to the triangle by the single subject and the

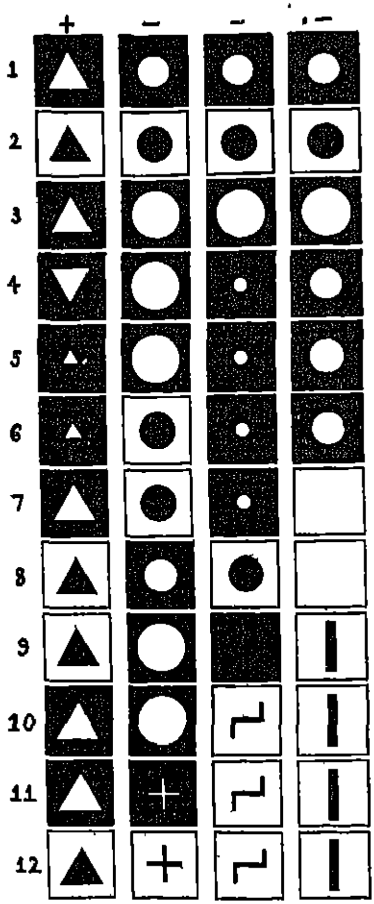

FIGURE 3

number of trials given during the different test periods is presented in Table 3. As shown in the table, inconsistent responses were obtained with only two combinations of stimuli, namely, those used in Tests 8 and 12, in which the animal pressed the lever corresponding to the white square and the horizontal arm of the swastika. At no other time was there any doubt of the efficacy of the figures in bringing about differential behavior. From direct observation and from moving pictures taken of the behavior during the tests,

TABLE 3

THE NUMBER OF TRIALS AND THE NUMBER OF RESPONSES TO THE TRIANGLE IN SITUATIONS INVOLVING DIFFERENT VISUAL PATTERNS

Situation	Number of trials	Number of responses to triangle
1. Standard triangle, 3 standard circles.	20	19
2 Black triangle, 3 black circles	3	3
3. Standard triangle, 3 large circles	3	3
4 Inverted triangle, large circle, small circle, and standard circle	3	3
5 Small triangle, large circle, small circle, standard circle	3	3
6 Small triangle, black circle, small circle, standard circle.	3	3
7 Standard triangle, black circle, small circle, white square	3	3
8. Black triangle, standard circle, black circle, white square	3	1
9 Black triangle, large circle, black square, black rectangle	3	3
10 Standard triangle, large circle, swastika arm, black rectangle	3	3
11 Standard triangle, white cross, swastika arm, black rectangle	3	3
12 Black triangle, black cross, swastika arm, black rectangle	3	2

evidence could be obtained that the cat made its discrimination three or four feet in front of the boxes, at which point it would sometimes stop, turn its head from box to box, and finally proceed directly to the triangle.

It is clearly evident from the results that the cat's discrimination of form is not a direct function of the relative size of the figures, nor of the particular luminosity relations between the figures and their backgrounds, whether in paired or in unpaired situations In addition, a great many different kinds of figures, unrelated to either the triangle or the circle, may possibly be said to take on negative significance and are so discriminated when they are introduced in place of one or more of the circles in the unpaired conditions as described above Finally, it may be held with assurance that the combination of figures responded to as equivalent in Tests 8-12 do not seem to possess any sort of constant interrelations nor any sort of total organization which may be described by the terms, "non-equilibration" or "figure-ground," as these terms have ordinarily been used by Kluver. Indeed, the data bearing upon the presentation of different forms show that situations lacking the characteristics implied in the definitions of such terms are just as effective in producing transfer of response as are situations distinguished by "imbalance" and "figure-ground" attributes.

4. *Transfer of Response between Situations Presenting Visual and Auditory Differences* The results secured in tests 9-13 in the experiments just described suggest that constant relational factors between differential stimuli are unnecessary in order that immediate transfer of response may take place in the discrimination situation This possibility may be explicitly tested by presenting a differential auditory stimulus to animals which have been trained on paired and unpaired visual forms, thus controlling the factor of relative intensity or size, which has existed in previous experiments of this sort (Hunter, 7; Kluver, 8). The question was therefore raised. will animals, trained in the discrimination between paired and unpaired visual patterns, give consistent responses, without further practice, to an auditory stimulus within one of the discrimination boxes, when all differential visual clues have been removed?

Seven animals (Subjects 8, 9, 10, 11, 13, 14, and 15) were used in the experiment. The first three animals had been employed in the experiments with paired visual patterns. Subjects 14 and 15 had been trained and tested in an unpaired situation consisting of four stimuli, while Subject 11 had been similarly trained and tested in a situation consisting of three figures Subject 13 learned a brightness discrimination habit (one white card versus two black cards) in an unpaired situation

The arrangement of the stimulus boxes was similar to that used in studies with the paired stimuli, except that the two boxes were placed diagonally at the two rear corners of the table, their front sides facing the center of the opposite end of the table. A buzzer was suspended on the inside of each of the stimulus boxes by means of rubber bands stretched between two small standards. The electrical current activating the buzzers was led through a transformer and a double-throw switch, mounted at the back of the table The position of the sound could thus be alternated between the two boxes by simply throwing the switch. The intensity of the two buzzers was approximately equalized by damping them Gray cards of uniform surface, each containing three slits, 10 2 cm. by 1 3 cm, were inserted in the doors of the discrimination boxes With six animals (Subjects 8, 10, 11, 13, 14, and 15), which could obtain food at the box where the buzzer was not sounding, no electrical punishment was employed Subject 9 was required to respond to the box in which the buzzer was sounding, and received a shock for touching the lever on the "silent" box

Each animal received a series of 20 or 30 consecutive test trials in a single evening, carried out with the usual precautions for the control of extraneous cues After the test periods had been given, an additional series of trials, in which no auditory stimuli were employed, was carried out.

Table 4 summarizes the results obtained with the seven animals in the situations studied Reference to the table will show that the avoidance response to the buzzer was unequivocally present and consistent in all of the animals during the test periods. Subject 9, even though shocked for a response to the silent box, gave some evidence of consistently avoiding the buzzer

TABLE 4

NUMBER OF TRIALS AND THE PERCENTAGE OF RESPONSES TO THE "SILENT" BOX IN SITUATIONS INVOLVING AUDITORY STIMULI

Subject	Number of test trials	Percentage response to "silent" box
8	20	90
9	20	75
10	30	80
11	20	100
13	20	95
14	30	80
15	20	80

The animals' behavior in these situations was not dependent upon whether paired or unpaired stimuli were learned during the preliminary training The subjects which were trained in the discrimination of paired stimuli responded as well as those which had learned either of the unpaired situations In this additional respect, therefore, no differences are to be found in the nature of response to paired and unpaired stimulus situations.

The responses observed were not a function of the electrical punishment, since six animals received no shock during the test periods Nor were other extraneous factors involved in the production of the differential behavior. In every case when the auditory stimulation was discontinued, the subject failed to give significant levels of discriminative response.

V. SUMMARY AND DISCUSSION

The results of the experiments in their entirety may be summarized as follows. Learning records of cats trained under three different conditions of stimulation failed to disclose sufficient differences in order qualitatively to distinguish paired stimuli from unpaired stimuli for the three animals in the situations investigated. Under four-stimulus conditions fewer trials may be required for eliciting a discriminative response than in two-stimulus situations, independently of the way in which electrical punishment is utilized in the paired situations, but this difference is offset in each case by a greater total number of responses to the negative figures. Because of the undetermined factors the three-stimulus conditions appear to be the most difficult arrangement used.

Data obtained from experiments in which paired stimuli were introduced for unpaired, and unpaired for paired stimuli, subsequent to the establishment of the initial discriminative response, are consistent with results obtained in the learning experiments in showing that the two situations involve similar "functional properties" in behavior. Animals learning unpaired stimuli reacted as well in other unpaired or in a paired situation, while those learning paired stimuli gave significantly consistent responses with the unpaired stimuli

Limited change in the size, position, and luminosity relations of the pattern in an unpaired situation did not modify the consistency of the responses. These results are similar to those of experiments carried out with paired stimuli in a previous study (Smith, 22), and demonstrate further the functional similarity of paired and unpaired stimuli in the behavior of the cat

Modifications were introduced in a four-stimulus situation by presenting different kinds of figures in the doors of each box, thus destroying any "unpaired" or "imbalance" character, in terms of number of stimuli, previously existing in the situation (Tests 8-12, Plate II). The results are the same as in the cases where non-differential aspects of the stimuli are changed. In other words, the four-stimulus situation, when lacking its previous unpaired character, is quite the same for the animal as when it possesses such features

A situation involving auditory stimuli was responded to consistently by seven animals, no matter whether they had been trained with paired or unpaired visual forms (Table 4).

Two series of experiments involved the presentation of situations in which the differential absolute values and the relational characteristics between the stimuli were entirely different from those upon which the animal had been trained (Tests 8-12, Plate II, auditory experiments, Table 4). It is evident from Plate II that not only are the relational characteristics between figures entirely different from those of the training situation, but also that such features differ among the various parts of the situation Moreover, with regard to the auditory stimuli, there are no known criteria by which it is possible to judge "no sound" and "triangle" or "sound" and "circle" as similar, constant, or identical, whatever may be one's point of view. The physical conditions of the significant stimuli in the two cases may thus have nothing in common, either perceptually or physically, save in so far as they are related to other aspects of the total situation in location, which remains practically the same

These results are believed to bear upon prior interpretations of transfer of response in the following manner.

Clearly, no support is given to the interpretations of Klüver (8) concerning the qualitative distinction between paired stimuli, as "equilibrated" or lacking figure-ground character, and unpaired stimuli, as "non-equilibrated" or possessing figure-ground character Indeed, this study not only shows that initial learning in paired and unpaired stimulus situations gives rise to few differences in respect to a criterion of trials, but also that where greater economy of trials can be found in the unpaired situations, this faster rate of learning is offset in each case by the greater amount of practice in responding to negative stimuli Whether this state of affairs can be found for various conditions of stimulation can not be predicted, but with the results in the case of pattern discrimination, in which neither the positive or negative stimuli seem to have an initial significance for the animals, this relation between economy of trials and number of negative responses is clearly indicated. In the present study the non-equilibrated situation, so-called, did not demonstrate itself to be superior in reducing the number of trials needed for learning and indeed it actually demanded a greater amount of practice in responding to negative stimuli. The need for Kluver's theoretical assumptions is therefore not evident.

Moreover, the *equivalence of paired and unpaired stimuli in giving rise to immediate transfer* of response, a fact inconsistently dealt with by Kluver (8) when his primary systematic assumptions are taken into consideration, necessitates either the rejection of his formulations centering about the relative functional import of paired and unpaired stimuli or the bringing up of the primary postulations themselves for examination The failure of inconsistent behavior to appear after a four-stimulus situation is so modified as no longer to possess its unpaired or "non-equilibrated" character discloses the lack of correlation between "non-equilibration" and transfer of response under the conditions studied. The *similar success achieved by cats, trained with either paired or unpaired stimuli, to transfer to a new differential situation involving an auditory* stimulus also points to the similarity of function in learning paired and unpaired situations Again, the idea of "equilibration," as set forth by Klüver, necessitates further explanation as to exactly how such situations are ever learned by the animal, if the term "equilibration" is to be taken at all literally. In addition, the idea of "non-equilibration" represents no more than the fact implied in the use of the expression "difference in stimulation," and does not even suggest in what direction an animal will respond in a modified situation. In the auditory experiments, here *reported, it might be expected from* Kluver's *analysis of* comparable *conditions in relation to the behavior of the monkey that the animal* would respond in the direction of the sound, since all other parts of the experimental situation might have been said to be "homogeneous" with reference to that point. All animals consistently avoided that point.

The present experiments offer further evidence as to the exact rôle played by the relative values of differential stimulus situations in controlling transfer of response Specifically, certain experiments (Tests 8-12, Figure 3, auditory experiments, Table 4) were devised to *present a situation such that the* differential relational values, as compared to those existing *during the training period, would* be entirely changed. The results show that immediate transfer of response takes place in the absence of these "common ratios of excitation" which, according to Lashley (12), are the common elements in producing constancy of response above the level of spinal reactions In other words, although transfer may be correlated in a way with what may be interpreted only roughly as common differential stimulus ratios, as Hunter (7), for example, found in the case of auditory and visual stimulation with rats, there is no concomitant correlation between all cases of the absence of common ratios of excitation and transfer of response The results can therefore be said to have an important positive bearing upon the general theory of constancy in behavior, since they show directly that factors other than common ratios of excitation must be considered as significantly correlated with the presence of transfer of reaction under differing stimulus conditions.

The present writer is not inclined to believe that further understanding of the responses found in the present experiments is reached by the postulation of different kinds of inherent physical similarity, or by circular arguments, by which inherent "perceptual" similarity is somehow made the controlling factor in behavior This latter explanation or description, it is believed, has been an illogical characteristic of early behavioristic, as well as more recent, accounts of transfer of response in animals. Rather, the suggestion is made that many stimulus factors related to the situation as a whole and to the past history of the animal must be kept in mind if experiments such as those just described are to lead to the scientific prediction of behavior

Of these factors it may be believed that the particular response, as here studied, and its genetic history, is most important in bringing about certain phenomena demonstrated in the present experiments Since discriminative behavior involves activities of avoidance and approach which have been related to all varieties of stimulation in the past history of the animal, the single necessity arises that such activity be coordinated with reference to a new setting of stimulus circumstances. The capacity for turning right and left, for avoiding such and such a stimulus and approaching (by necessity) another different complex of external disturbances, is one partly developed before birth, and, by its further development in relation to all varieties of stimulation after birth, functions as a large part of the normal activity of the animal throughout life. Since there is little reason to suppose that a naive animal is being used at the start of experiments of this sort, prediction of response must be based in part upon the stimuli previously significant in the past history of the animal, as in the case of the results with auditory stimuli, cited above The most general statement of the principle by which older stimuli are thus incorporated into new combinations of excitation is that of "redintegration" or part-whole substitution.

Another factor demanding close consideration in experiments with transfer in behavior is the drive stimulus, the importance of which has been only partly appreciated in the past by investigators in this field (Hull, 5). In the first place, the drive stimulus, consisting of some internal excitatory condition, aroused directly by the demand for food or indirectly by any chance association, determines the fact that, during the initial periods of learning in a new total situation, almost any stimulus will be responded to (approached) as equivalent, and the greater the drive or hunger, the less selective will be the behavior of the animal In the second place, and more important for the understanding of discriminative behavior as it has been here demonstrated, the drive stimulus is responsible for the effectiveness of either similar or dissimilar ratios of excitation in behavior The forced character of response, insured by the drive stimulus, brings it about that reaction takes place in one or another direction, irrespective of the general kinds of stimulation presented in the discrimination boxes or in the situation as a whole. The fact that the organism when hungry must always react, that is, the necessity imposed upon it for approaching another source of stimulation when avoiding one source, or leaving one source after contact, makes it inevitable that changes or differences in stimulation (relations), rather than any sort of arbitrarily defined absolute units, take on significance *It is also inevitable that learning and development should proceed with reference to such changes or differences (relations) in stimulation Selection and consistent discrimination (restriction and classification of stimuli into identical and non-identical groups), according to the demands of the organism, arise as a result* of learning and development, which also serve to establish the direction of response with reference to such changes and *differences* in stimulation.

VI. CONCLUSIONS

1 Learning records of cats trained under three different conditions of stimulation failed to disclose differences of a sort that make it possible to distinguish paired stimuli from unpaired stimuli for the animals in the situations investigated A fewer number of trials may be required for establishing discriminative behavior when four stimulus patterns are employed than when either three or two stimulus patterns are used, but this difference is offset in each case by a greater total number of responses to negative figures in the four-stimulus conditions.

2 Data obtained from experiments in which paired stimuli were introduced for unpaired, and unpaired for paired stimuli, subsequent to the establishment of the primary discriminative response, show that the two types of situations involve similar functional properties in behavior Animals which learn unpaired stimuli react as efficiently in other unpaired as well as in paired situations, while those which learn paired stimuli give significantly consistent responses with unpaired stimuli

3 Changes were introduced into a four-stimulus situation by modifying the differential and secondary non-differential aspects of the stimulus patterns. The results show that the cat's discrimination of visual patterns in such unpaired situations is comparable to that observed with paired stimuli in a previous study (Smith, 1934)

4 Additional evidence as to the similar effects of training with paired and unpaired stimuli was secured by transferring seven animals to a situation presenting differential auditory stimulation Significantly consistent responses were found in the case of all seven subjects in the new situation, no matter whether training had been carried out with paired or unpaired visual patterns

5 The experiments with the auditory stimuli demonstrate also that transfer of response may take place between situations presenting no common, differential, absolute, or no common, differential, relative properties, when such properties are defined in either physical or perceptual terms.

6 The results may be interpreted as being contradictory to the views that stimulus equivalence and transfer of response depend upon the presence of common ratios of neural excitation (Lashley, 1934) or upon common perceptual or phenomenal relations (Gestalt the-

ory) alone. Both of these views fail to take into proper consideration a most fundamental fact in discriminative behavior, viz., the incorporation of previously effective modes of stimulation into responses reorganized with reference to present stimulus complexes, whether or not differential parts of such complexes are related to the formerly effective stimulation A more consistent view, which is, in addition, based upon empirically known facts about stimulation and behavior, is presented as an account of the transfer of response in situations involving dissimilar, as well as roughly similar, relative values of stimulation.

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LA DISCRIMINATION VISUELLE CHEZ LE CHAT III L'EFFET RELATIF DE STIMULI MIS EN PAIRES ET DE STIMULI SEULS DANS LE COMPORTEMENT DISCRIMINATIF DU CHAT

(Résumé)

Un aspect adaptif du comportement est le fait que des formes consèquentes ou constantes de réponse peuvent être données aux stimuli qui varient considérablement dans leurs caractéristiques mesurables ou objectives L'expérimentation antérieure a montré que ce trait du comportement des animaux auquel divers auteurs ont donne des noms différents comme "formation des concepts," "abstraction," "généralisation," "induction," "transfert de l'entrainement," "transposition," "équivalance fonctionnell des stimuli," et "constance sensorielle," joue un rôle variant dans l'ajustement de tous les animaux vivants à leurs environs Dans cette étude-ci, on a formule des expériences pour constater les facteurs qui causent une telle constance ou transfert de la réponse dans le comportement discriminatif du chat dans des situations de stimuli mis en paires et seuls

Les notations de l'apprentissage des chats entraines avec des formes visuelles mises en paires et seules n'ont montré aucunes différences qui le rendrait possible qualitativement de distinguer les stimuli mis en paires et les stimuli seuls pour les animaux dans les situations étudiées Dans des conditions de quatre stimuli moins d'epreuves peuvent être nécessaires pour faire venir le comportement discriminatif que dans les conditions de deux stimuli,

mais cette différence est compensée dans chaque cas par un plus grand nombre total de réponse aux figures négatives. Une situation de stimulus seul comprenant trois formes visuelles a été la plus difficile des situations employées.

Les données obtenues des expériences ou des stimuli mis en paires ont été introduits pour les stimuli seuls, et des stimuli seuls pour les stimuli mis en paires, subséquent à l'établissement de la réponse discriminative primaire, montrent que les deux situations *comprennent des propriétes fonctionnelles* semblables dans le comportement du chat. Les animaux qui ont appris des stimuli seuls ont réagi avec le même efficaciteé dans d'autres situations seules ou mises en paires, tandis que ceux qui ont appris des stimuli mis en paires ont donné aussi des réponses constantes d'une façon signifiante avec les *stimuli seuls*

On a introduit des modifications dans une situation de quatre stimuli au moyen de présenter diverses sortes de figures au lieu des stimuli négatifs employés dans l'entraînement. *Les résultats montrent que la discrimination* des formes visuelles par le chat dans de telles situations seuls est comparable à celle observée avec les stimuli mis en paires dans les études antérieures.

Une situation comprenant des stimuli auditifs a été discriminée tout de suite par sept animaux après que l'entraînement avait été fait avec des *formes visuelles. Les animaux entraînés* avec des stimuli mis en paires ont réagi aussi bien que ceux qui ont appris les formes visuelles en paires.

Les expériences avec les stimuli auditifs montrent aussi que le transfert de la réponse peut avoir lieu entre les situations qui ne présentent nulles propriétés communes, différentielles, absolues, ni des propriétés communes, différentielles, relatives, quand de telles propriétés sont définies ou en termes physiques ou en termes perceptifs.

On interprète que les resultats s'opposent à l'opinion que l'équivalence *des stimuli et le transfert de la réponse dépendent de la présence de proportions* communes de l'excitation neurale ou de relations communes phenoménales ou perceptives seules. On suggère une vue plus conséquente qui rend compte du fait que des caractéristiques communes des stimuli ne sont pas nécessaires aux stimuli équivalents par le fait qu'ils peuvent devenir équivalents quand ils agissent comme "signes" pour le comportement adaptif, qui depend de l'apprentissage antérieur ou des formes fondamentales de réponse de l'animal

SMITH

GESICHTSUNTERSCHEIDUNG BEI DER KATZE III DIE RELATIVE WIRKUNG DER GEPAARTEN UND UNGEPAARTEN REIZE BEI DEM UNTERSCHEIDUNGSVERHALTEN DER KATZE

(Referat)

Eine *Anpassungsseite des Verhaltens* liegt in der Tatsache, dass übereinstimmende oder fortdauerende Muster der Reaktion den Reizen gegeben werden konnten, die in ihren messbaren oder objektiven Eigenschaften beträchtlich variieren konnen Vorangehende Experimentierung hat bewiesen, dass diese Eigentumlichkeit des Tierverhaltens, die verschiedenerweise von verschiedenen Forschern benannt wurde, wie "*Begriffsbildung*," "*Abstrak-*

tion," "Verallgemeinerung," "Induktion," "Fahigkeitsubertragung," "Umstellung," "Funktionsgegenwert der Reize," und "Sinnesbestandigkeit," sich zu verschiedenen Graden bei der Anpassung aller lebenden Tiere an ihre Umgebung bezieht. In der vorliegenden Untersuchung wurden Experimente angestellt, um die Faktoren festzustellen, die solch eine Bestandigkeit oder Übertragung der Reaktion in dem Unterscheidungsverhalten der Katze bei gepaarten und ungepaarten Reizsituationen erzeugen

Die Lernwerte der Katzen, die mit gepaarten und ungepaarten Gesichtsmustern trainiert wurden, offenbarten keine Unterschiede der Art, die ermoglichen wurden, gepaarte Reize von ungepaarten Reizen bei den in den Situationen untersuchten Tieren qualitativ zu unterscheiden Bei Vier-Reiz-Situationen wurden weniger Versuche zur Hervorrufung des Unterscheidungsverhalten nötig als bei den Zwei-Reiz-Situationen, aber dieser Unterschied wird in jedem Fall der grosseren Gesamtzahl der Antworten auf negative Figuren gegenubergestellt Eine ungepaarte Reizsituation mit drei Gesichtsmustern war die schwierigste der angewandten Situationen.

Die Ergebnisse von den Experimenten, bei denen gepaarte Reize anstatt ungepaarter, und ungepaarte anstatt gepaarter eingefuhrt wurden, nachdem die erste Unterscheidungsreaktion festgesetzt wurde, beweisen, dass die zwei Situationen ähnliche Funktionseigenschaften in dem Verhalten der Katze enthalten Die Tiere, die ungepaarte Reize lernten, reagierten genau so wirksam bei anderen ungepaarten oder in gepaarten Situationen, wahrend diejenigen, die gepaarte Reize lernten, gaben auch bedeutsam ubereinstimmende Reaktionen mit den ungepaarten Reizen.

Veranderungen wurden bei einer Vier-Reiz-Situation durch die Darbietung verschiedener Arten von Figuren anstatt der negativen Reize, die bei der Übung gebraucht wurden, eingefuhrt Die Ergebnisse zeigen, dass die Unterscheidung bei der Katze der Gesichtsmuster in solchen ungepaarten Situationen mit der vergleichbar ist, die mit gepaarten Reizen in vorangehenden Experimenten beobachtet wurde.

Eine Situation mit Gehorreizen wurde unmittelbar von sieben Tieren unterschieden, nachdem die Übung mit Gesichtsmustern ausgefuhrt worden war Die Tiere, die mit gepaarten Reizen trainiert wurden, reagierten genau so gut wie die jenigen, die mit gepaarten Gesichtsmustern lernten

Die Experimente mit den Gehorreizen beweisen auch, dass die Übertragung der Reaktion zwischen Situationen stattfinden kann, die keine gemeinsamen, unterscheidenden, absoluten, oder keine gemeinsamen, unterscheidenden, relativen Eigenschaften darstellen, wenn solche Eigenschaften in entweder physikalischen oder Wahrnehmungsausdrucken definiert werden

Die Ergebnisse werden als der Ansicht widersprechend angesehen, dass Reizgleichwert und Übertragung der Reaktion von der Anwesenheit der gemeinsamen Verhaltnisse der Nervenreizung oder von gemeinsamen phanomenalen oder Wahrnehmungsverhaltnissen allein abhangig seien Eine haltbarere Ansicht wird vorgeschlagen, die die Tatsache erklart, dass gleichwertige Reize keine gemeinsamen Reizeigenschaften brauchen, durch die sie gleichwertig werden konnen, wenn sie als "Zeichen" fur Anpassungsverhalten dienen, die von dem vergangenen Lernen oder den Grundreaktionsmustern des Tiers abhangen

SMITH

COLOR VISION IN WHITE RATS: I. SENSITIVITY TO RED*

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Our general problem was to see whether white rats can form habits based on a discrimination of differences of wave-lengths. As our study progressed we limited ourselves to the difference between the red band of the spectrum and gray or a wide region of heterogeneous wave-lengths.

Previous experiments on the color vision of white rats have consistently produced negative results (1, 2, 3, 6) with one exception (5) Since we shall have occasion in the course of this report to refer to methods and results of other experimenters we shall refrain at this time from analyzing their work

GENERAL CONSIDERATIONS

If the white rat possesses color vision at all, previous attacks on the problem would lead one to believe that it must be an aspect of its behavior which is extremely difficult to utilize in a discrimination habit The question which one will have to bear constantly in mind is therefore: What would be the most favorable conditions for color vision? We shall list here a number of such conditions which we utilized in our experimental procedure.

1. The perception of color depends on the intensity of the stimulus; below a certain intensity threshold spectral colors become grays. It is possible that this threshold is rather high for the rat We used color filters which have the advantage that they permit of combining high intensity with large size.

2. Bands of homogeneous wave-lengths are not essential to color vision in the case of the human eye, which does not discriminate between colors produced by homogeneous wave-lengths and "the same colors" produced by heterogeneous wave-lengths. The rat's visual processes may be quite different. The most favorable situation

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would therefore be the one using very homogeneous wave-lengths. If there is no possibility of constructing an apparatus similar to the one described by Yerkes and Watson (7) and if one has no access to a spectroscope, it would seem to be safer to use color filters, whose transmitted wave bands are known, rather than colored papers whose colors may appear to be the same to the human eye but which may actually reflect wider bands of wave-lengths.

3. Since it is so very easy to establish a brightness habit in the white rat, the animal should, if possible, be prevented from forming such a habit. Methods should be adopted which might lead to a confusion of brightness habits Despite the use of such methods one should constantly suspect the existence of brightness habits. Especially should one refrain from applying the brightness standards of the human eye to the situation in which the rats are discriminating Where a brightness habit would be ruled out in discrimination by human subjects such a habit might still operate in the case of rats As Munn has pointed out and demonstrated (2, 3) we must use the rat's own behavior to determine the brightness values of its color stimuli. It is only a method utilizing a knowledge of such values that is capable of counteracting a brightness discrimination habit, or that, in other words, creates a situation favorable to the emergence of a habit based on color discrimination.

4 Since electric shock may force an animal to attend to cues otherwise neglected and since it reduces the time required to form a discrimination habit by about two-thirds, its use will also contribute to make the situation favorable to learning on the basis of color vision

Apparatus and Methods

The apparatus was a Y-shaped discrimination box shown in Figure 1. Two 15-watt frosted light bulbs, l_1 and l_2, illuminated the stimulus patches s_1 and s_2, which appeared on sliding doors made of framed frosted glass with the frosted side towards the animal. The color stimuli consisted of Wratten gelatin color filters, 4 x 4 inches, held between two pieces of glass of the same size These filters were attached to the sliding doors on the side towards the light bulbs. Black strips of paper cut the illuminated opening down to 3½ x 3½ inches When no color filter was used this opening provided a "gray" stimulus The apparatus was painted lamp black A lid

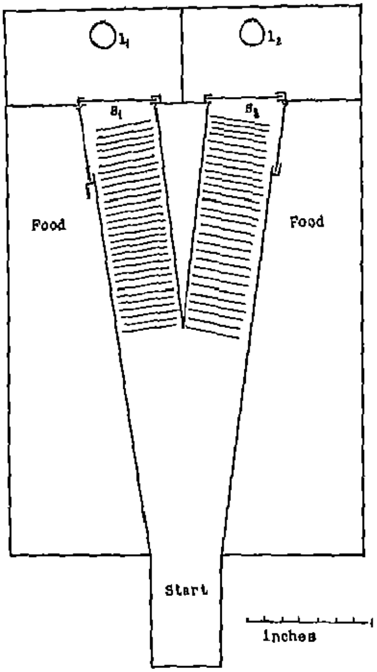

FIGURE 1

with two heat outlets over the light bulbs covered the light chambers and the rest of the apparatus up to the point of choice.

Two Wratten color filters were used, a red (*"F"*) transmitting 610 mμ and up, and a green (*"B"*) transmitting 460-600 mμ. No check was made to see whether these factory specifications were accurate. The animals were trained red-positive. The green filter was used only in the first two parts of the experiment while for the rest a gray was used instead, that is, the stimulus patch without the green color filter.

In order to change the intensities of these stimuli the light bulbs were operated from a rheostat which divided the 110-volt lighting current into ten different voltages as follows:

Rheostat point	1	2	3	4	5	6	7	8	9	10
Voltage	110	75	67	60	55	50	45	40	30	0

In indicating the intensities of the stimuli we shall add the rheostat point to the quality. Thus red-1, green-1, and gray-1 indicate that these qualities were used with maximum intensities. Green-5 indicates that the current of the light bulb behind the green filter was reduced to 55 volts. Gray-10 indicates that the bulb was not lighted at all. Dimming the source of light by means of a rheostat, though convenient, is not an ideal method, its shortcomings may account for the animal's difficulty in discriminating between red and a gray of low intensity since this gray may have contained a larger amount of long wave-lengths than the brighter gray.

In the last part of the experiment a milk glass was placed between each light bulb and the sliding doors in order to decrease the intensities evenly for both stimuli.

There was no flicker photometer available to measure the intensities used. A series of measurements with a Westinghouse "Lightmeter," style 838094-D, gave the following values in foot candles when the instrument was placed one inch from the stimulus patches:

	Red-1	Gray-1	Gray-9	
Without milk glass	$1\frac{2}{3}$	50	1	foot candles
With milk glass	$\frac{1}{3}$?	9		foot candles

Six albino rats of Wistar strain, six weeks old at the beginning of the experiment, were used. They were motivated by a 23-hour fast. The goal in the apparatus consisted of cheese crumbs. After the daily runs the rats were fed a standard diet for half an hour. Punishment for incorrect responses was administered by an alternating current of 0.11 milliampere, which was obtained from an 1100-volt transformer and a resistance of 10 megohms in series with the grid.

Each animal was given ten trials per day during the earlier parts of the experiment and 20 trials per day during the later parts. The sequence of presenting the positive stimulus was R(ight) L(eft) RRLRLRRL and LRLLRLRLLR for two series of ten trials.

The experiment was carried on in a dark room in which the only illumination for the experimenter was a shaded 10-watt bulb.

THE RESULTS

Part A. As mentioned above, Munn has suggested (2, 3) that in animal experiments one must determine brightness values for the animal's eye and not rely on human judgment. Following his suggestion we tried to find in a preliminary experiment a green similar in brightness to red-1. Two rats learned a red-1 . green-1 discrimination without difficulty. When the negative stimulus was reduced to green-3 the habit broke down "Breaking down" here means a reduction of correctness to somewhere near 50 per cent with large variations, it does not mean a persistent 50 per cent choice of the positive stimulus

Part B. We then trained four new rats on red-1 · green-3 After 80 trials there was some indication of learning in two rats. So we decided to counteract the formation of a brightness habit by varying the intensities of the stimuli in this way: For ten trials we reduced the current of the left light bulb, for the next ten that of the right bulb, and so on, while the color stimuli were shifted as before according to the pattern of sequences To the human eye the brightness relations between the two stimuli were. red-3 much darker than green-1, and red-1 almost the same as green-3. After forty trials there was definite evidence of learning, at least in two rats; the numbers of correct turns for trials 101-120 were 19, 20, 15, 10 for the four rats respectively.

We then reduced the brightness another step. For the human eye green-4 was now of the same brightness as red-1 Continuing with the same method of dimming the left light on one day and the right one the next we got the following results· On trials 171-210 the numbers of correct turns were 36, 37, 35, and 32 for the four rats, a high degree of correctness In a control series we now checked for extraneous cues: For 30 trials we used no shock, employed a new sequence of turns, and let an assistant handle the rats. The correct turns for the 30 trials were 30, 27, 29, and 28

Continuing, we reduced the brightness again For the human eye green-5 was now distinctly darker than red-1, while green-1 was very much brighter than red-5 In trials 321-370, in addition to the controls mentioned in the last paragraph, we shifted the filters without shifting the sliding doors or frames During these 50 trials the correct runs were 46, 45, 49, and 45 Since it was possible that the gelatin filters, which were slightly warped, might have produced patterns of lighter and darker color, we substituted red and green glass for them. With the right light dimmed to position 5 the correct turns for the ten trials were ten, ten, ten, eight.

Taking these results at their face value they would indicate the presence of color vision in the rat They agree well with the results of Walton's experiment where a similar method of alternately reducing the positive and negative stimulus was used (5).

Part C. Although the red towards which the animals were turning appeared to the human eye brighter than a green at one time and darker the next time we were not certain that the same relations were true for the rat's eye Since a further reduction of the brightness of these colors might have turned them into grays for the animals we decided to use from now on only red-1 and vary only the brightness of the negative stimulus which from now on was to be gray instead of green In particular it was our aim to see whether the rat could choose a red that was paired with a white (full intensity of gray, our gray-1) at one time and a black (light turned off) the next time, and whether we could vary the grays from white to black without breaking down the habit.

In the first ten trials, 381-390, red-1 was paired with gray-1, or white The correct turns were ten, ten, ten, nine In the next ten trials gray-10, or black, was used with the result that the rats practically refused to run Only the first rat completed its ten trials *with one correct turn,* indicating a transposition effect of a brightness-relation habit The animal had learned to go to the darker of the two stimuli Evidently green-5 in the former trials, although darker than the red-1 for the human eye, was brighter for the rat's eye. It is very improbable, therefore, that the rats in our part *B* and in Walton's similar situation were choosing on the basis of a discrimination of wave-lengths These negative results are in line with those of Munn (3) who used a blue yellow discrimination

If gray-10 is darker than red-1 for the rat's eye there must be a gray lying between gray-1 and gray-10 which is equal to red-1 in brightness We decided to find such a gray

There was no difficulty with gray-5, for 20 trials the correct turns were 20, 17, 18, and 18

Slight difficulty was experienced with gray-6, which in the first 20 trials gave the results 14, 13, 16, and 13; and in the next 20 trials 16, 17, 12, and 11.

Going on with gray-7 the first 20 trials yielded 12, 13, 14, and 12 correct turns. Further training of 50 trials with gray-7 did not, at this time, improve the rats' correctness (it did so later). We thought we had approached the point where the gray equaled the red in brightness. If this were so, the next step ought to give us pure chance results or even a transposition effect

With gray-8 the first 20 trials yielded 13, 13, 10, and 9 correct turns No clear-cut results, at least for two rats. Further exploration did not produce a consistent 50 per cent choice at any point.

Part D We were now afraid that we were confirming the rats in their brightness habit and in order to break this habit we decided to give them 20 trials a day from now on (trial 361) and to use a gray brighter than red-1 in one set of ten trials and a darker gray in the other set of ten trials.

For the next 18 days we paired red-1: gray-1 (white) in one set of ten trials and red-1 gray-10 (black) in the other set of ten trials of the same day, starting alternately with one or the other on different days

With gray-1 as the negative stimulus the rats ran practically with a 100 per cent correctness from the start

On the same days with gray-10 as the negative stimulus there were marked individual differences. To our surprise the first two rats started with 19 correct turns each in 20 trials, how was this to be explained in view of their poor showing with gray-7 and gray-8 just above? The last two rats started with five and ten correct turns out of 20 trials. But on the ninth and tenth days they also made 19 correct turns each out of 20 trials with gray-10 From the thirteenth to the seventeenth days we used various controls as above in order to check for extraneous cues, the result was negative. On the eighteenth day normal conditions were used again · with red-1 gray-1 there were ten, nine, ten, and ten correct turns for ten trials, and with red-1 :-gray-10, there were ten, ten, nine, and ten correct turns out of 10 trials.

Now we had achieved the aim in which we had failed in part *B* The animals discriminated a red from another stimulus which was at times brighter and at times darker than the red. But what did the results mean? Only further experimentation could suggest a valid explanation

Part E If the rats were discriminating a rather narrow band of wave-lengths (red) from a wide band of heterogeneous wave-lengths they should now be able to discriminate a gray of any brightness from red We therefore gave them a set of 20 trials in which the grays ranged from gray-1 to gray-10 and were changed every two trials That is, gray-1 was given the first two trials, gray-2 the next two, gray-3 the next two, and so on The correctness was high, namely, 20, 19, 18, and 17 correct turns, but five of the six errors were made with gray-9.

The next day, as a further check, we compared gray-10 with gray-9 Gray-10 yielded ten, ten, nine, and ten correct turns out of ten trials and gray-9 yielded eight, seven, six, and four correct turns out of ten trials. There was no doubt that gray-9 represented a difficult point in the gray series, but, again, it was not a point that gave pure chance results.

Our next effort was now directed towards a special training of the rats with gray-9. After 110 trials the rats reached a fairly high efficiency In the last 20 trials (1191-1210) they made 18, 17, 18, and 16 correct turns For several days we then presented them with gray-9 and another gray on the same day without a loss of efficiency.

As a final test we again gave them 20 trials with all the grays in our series from white to black The results were 19, 18, 19, and 19 correct turns, but all five errors were again made with gray-9! Our special training with this gray had not been sufficient to increase their correctness in this situation

As another test we gave them a series of 20 trials in which gray-9 alternated with another gray every two trials as follows. gray-5, gray-9, gray-6, gray-9, gray-7, gray-9, gray-8, gray-9, gray-10, gray-9 The results were 20, 16, 18, and 15 correct turns. The errors were distributed as follows. The first rat none (color vision?); the second rat four errors on gray-9 out of a possible ten, The third rat two errors on gray-9, and the fourth rat three errors on gray-9, one on gray-8, and one on gray-5

The next day we repeated the same series and got eight, eight, twelve, and six correct turns for the 20 trials. We felt baffled. Had the situation become so difficult that the animals "gave up" as a dog will "give up" when he has to discriminate between a circle and an ellipse that is only slightly different?

Part F If gray-9 is difficult while gray-1 and gray-10 are easy, a uniform reduction of the brightness relations should not disturb this situation much. Such a reduction was achieved by placing a piece of milk glass between each light bulb and stimulus patch. In order to indicate the reduced brightness values we shall add the letter "*m*" to the designations of the stimuli.

With this new condition the rats had no difficulty when they had to discriminate red-1*m* : gray-1*m*, the correct turns for the first ten trials (1241-1250) were ten, ten, ten, and nine. But when they faced red-1*m* : gray-10*m* in the next ten trials the correct turns were five, seven, eight, and five. This black, gray-10*m*, was the same as the black, or gray-10, used formerly, placing an object in the light chamber when the light is turned off should not make any difference in the appearance of the stimulus patch. The animals' difficulty must have arisen through the reduction of the red from red-1 to red-1*m*.

We then trained the rats on gray-10*m*. Each day we presented red-1*m* gray-10*m* for ten trials and the same red with another gray for another ten trials. There was no difficulty in the region between gray-1*m* and gray-5*m*. After ten days we trained only with gray-7*m*, gray-8*m*, gray-9*m*, and gray-10*m*, but did not use the last one every day as before. The result was that during the next 18 days the correctness rose with all of them, with gray-7*m* and gray-8*m* very quickly, next with gray-10*m*, but only slightly with gray-9*m*. For four more days we trained with gray-9*m* only. On the last 20 trials (1881-1900) the correct turns were 15, 16, 15, and 13. (A higher correctness with this gray was achieved later.)

There was an interruption of six weeks after which, for six days, we used all grays each day, and each gray for two successive trials.[1] The first animal made an excellent record again, it made six errors in these 120 trials and only one error was with gray-9*m* out of a possible 12. *Did this mean color vision?* (*During the rest of the experiment*, for another 550 trials, this animal's correctness dropped below 80 per cent only on four sets of ten trials under the conditions described below.) The second animal made 17 errors in these 120 trials, four of which were made with gray-9*m* out of a possible 12. In 120 trials the third animal made 17 errors, six of which were on gray-9*m* out of a possible 12. In 100 trials the fourth animal made 18 errors, five of which were on gray-9*m* out a possible ten.

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[1] We wish to thank Mr. Milford Fletcher for his assistance in the experiment from this point on to the end.

For the next 200 trials we used gray-10*m* every day for one set of ten trials and alternately gray-1*m*, gray-8*m*, and gray-9*m* for the other set of ten trials The correctness was high, seldom under 90 per cent for all except gray-9m for which it was very variable

In order to explore the distribution of the difficulty in the neighborhood of gray-9*m* we tapped the rheostat at various points between positions 8 and 9 and between 9 and 10 The results of 300 trials showed that the rats had again reached a fairly high degree of accuracy in this difficult region of grays, and that no point could be found in this region where the discrimination broke down During the last 20 trials with each of four different shades the correct turns for gray-8½*m* (35 volts) were 19, 20, 18, and 17; for gray-9-*m*, 18, 20, 13, and 18, for gray-9¼*m* (25 volts), 19, 18, 16, and 17, for gray-9½*m* (20 volts), 20, 19, 14, and 20.

On the last two days we again used all grays, each one for two successive trials on each day. The results for the two sets of 20 trials (2531-2570) were as follows The first animal made two errors on gray-9*m*, the second, one error on gray-8*m*; the third, two errors on gray-9*m*, and the fourth, two errors on gray-8*m*, one on gray-7*m*, and one on gray-5*m*, each type of error out of a possible 4. The end was characteristic of the whole experiment. Perfect discrimination between the red and the two ends of the gray series and difficulties with intermediate grays near the dark end.

Here we broke off the experiment When we asked Dr Munn whether he would care to give our four rats some tests in his laboratory he kindly expressed his willingness to do so His results are presented in the following article (4). We cannot conclude without expressing our gratitude to him for his interest and his labors without which we might have hesitated to publish our results

Summary and Discussion

In the first two parts of the experiment, using Wratten color filters, we found that white rats could learn to discriminate red and green stimuli and that they continued to discriminate correctly even if, to the human eye, the red stimulus was alternately darker and brighter than the green stimulus. Under such conditions four rats achieved a high degree of correctness which would indicate the presence of a habit based on color discrimination, provided one assumed the rat's visual processes to be the same as those of the human eye.

TABLE 1

SUMMARY OF RESULTS

	Percentage of correct turns for rats					
Conditions	1	2	3	4	Trials	Comments
Part *B*						
red-1:green-5 red-5:green-1	94	92	100	92	100	Simulating color vision; actually brightness discrimination
Part *C*						
red-1:gray-1	100	100	100	90	10	Brightness-relation habit
red-1:gray-10	10					
red-1:gray-5	100	95	95	90	20	No difficulty with light grays
red-1:gray-8	65	90	55	45	20	Difficulty with dark grays
Part *D*						
red-1:gray-1	98	98	100	100	50	After training with alternate
red-1:gray-10	96	96	100	92	50	series of gray-1 and gray-10 as negative stimuli on the same day: *Response to absolute brightness*
Part *E*						
red-1:all grays	100	95	90	85	20	5 of the 6 errors on gray-9
red-1:gray-9	85	70	55	55	20	At beginning of training
	90	95	90	90	20	After 120 trials
red-1:all grays	95	90	95	95	20	5 errors on grey-9.
Part *F*						
red-1*m*:gray-1*m*	100	100	100	90	10	Reduced intensities.
red-1*m*:gray-10*m*	50	70	80	50	10	Reversion to brightness-relation habit?
red-1*m*:gray-10*m*	95	95	85	80	20	After training with intermediate
red-1*m*:gray-9*m*	75	80	75	65	20	grays; response to absolute brightness reestablished.
Interruption of six weeks						Gray-9*m* more difficult than gray-10*m*.
red-1*m*:gray-10*m*	100	100	100	100	20	After 100 trials with gray 10-*m*
red-1*m*:gray-1*m*	100	95	100	100	20	and 100 trials with intermediate grays in alternate series
red-1*m*:gray-9*m*	90	100	65	90	20	No break-down at grays between
red-1*m*:gray-9¼*m*	95	90	80	85	20	gray-9*m* and gray-10*m*:
red-1*m*:gray-9½*m*	100	95	70	100	20	*Response to light wave differences?*
red-1*m*:all-grays	95	97½	95	90	40	9 errors, 4 on gray-9*m* out of a possible 16

In part C of the experiment gray was substituted for green as the negative stimulus. The four rats discriminated perfectly red: white; but in the case of red · black three of them refused to run while one showed an almost perfect transposition, that is, it went to the darker of the two stimuli Evidently what had appeared to be a habit based on color vision when red and green were used was in fact a brightness-relation habit Given this habit there should have been a gray with the same brightness as the red. An extended exploration did not reveal such a gray, that is, we did not find a gray intermediate between black and white which if paired with red produced responses that were 50 per cent correct.

In part D we attempted to break the brightness habit of the animals by using on the same day alternately for ten trials the brightest gray and for ten trials the darkest gray of our gray series Marked individual differences appeared at first, but in the end all four rats chose red with a high degree of accuracy when confronted either with red white or with red:black in alternate series of ten trials. We consider this the outstanding result of our experiment. This behavior can only be explained by assuming that the original brightness-relation habit had now been replaced by another habit which was based either on the response to an absolute degree of brightness or on the discrimination between two stimuli one of which was produced by a narrow band of homogeneous wave-lengths (red) and the other by a wide band of heterogeneous wave-lengths (gray)

In part E we tried to decide which of these two alternatives would be the valid explanation, but the answer we got was equivocal. As a test we used on a single day not only the extremes of our gray series but also all intermediate grays Here the animals broke down at a single gray, the one nearest to the dark end of our series If we had omitted this particular gray we might have misjudged our results and concluded our experiment at this point.) This behavior seemed to indicate the existence of a habit based on a response to an absolute brightness

We then tried to see whether the rats could learn to discriminate between the red and the particular gray that had just caused a breakdown of the discrimination A fairly high accuracy was soon established at this point, but with considerable daily variations. It is possible that the rats were now using a habit which was based partly on a response to an absolute degree of brightness and partly on a discrimination between red and gray

Of course, it is also possible that the particular gray used here was so near the gray represented by the red that the rats had difficulty discriminating between them and yet the two were different enough that they could get a fairly high accuracy. This explanation would exclude the existence of a partial habit based on wave-length discrimination. Yet the results of the next part of the experiment, in particular our *exploration with very slightly different shades of gray* near the point of greatest difficulty, do not favor such an explanation

In part *F* we reduced evenly the brightness values of all stimuli, the red as well as the series of grays, with the result that it was difficult now for the rats to discriminate between the darkened red and the black. Further training, however, produced a high level of accuracy again.

In terms of brightness habits this unexpected difficulty might be explained thus Confronted with a darker red the rats fell back upon their original brightness-relation habit; this led to perfect results with red·white and to difficulties with red black Further training, which produced the discrimination red:black side by side with red: white, superimposed a habit based on a response to absolute brightness similar to the one seen in part *D*.

We now tested the rats on the intermediate grays and found again a large zone of difficulty near the black end of the series as in part E. Training with grays of this zone increased the correctness of discrimination and it also showed that this gray, which in our series was nearest to the black, again presented the greatest difficulty. Further exploration on either side of this particular gray with grays only slightly different produced no break-down The negative part *of these results is important: No point was found where discrimina*tion broke down completely; there was merely a region of optimum difficulty

These results—perfect discrimination between red and the two ends of a gray series and imperfect discrimination, but no breakdown, at an intermediate gray—seem to indicate that upon the primary brightness-relation habit and the secondary absolute-brightness habit there was superimposed *a weak wave-length discrimination* habit. It may be added that the results are in several cases due to the fact that training produced a discrimination which a first test failed to disclose.

CONCLUSION

White rats choosing a red which is, to the human eye, alternately darker and lighter than a green do not necessarily exhibit color vision.

Rats can be trained, however, to choose red consistently when confronted alternately with red. white and red·black

These animals will also learn to choose red when this is paired with any gray intermediate between white and black, although they will exhibit a reduced accuracy at a gray lying near the black (It was not shown whether much prolonged training in this region of difficulty would produce perfect accuracy.) It is assumed that the rats in this case possess a hierarchy of discrimination habits consisting of a primary brightness-relation habit, a secondary absolute-brightness habit, and a weak color-discrimination habit[2]

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[2] We realize better than any critic may do the unsatisfactory character of this experiment Our justification for publishing it was the confirmation of our results by Dr Munn as reported in the following article (4) and our desire to demonstrate certain difficulties of the problem of wave-length discrimination in animals What we have done should be considered an exploration Only a systematic variation of many factors can elucidate the rôle which color vision—if it exists at all—plays in discrimination habits of white rats.

DISCRIMINATION OF RED BY WHITE RATS*

From the Psychological Laboratory of the University of Pittsburgh

Norman L. Munn and Marjorie Collins

Introduction

This investigation, undertaken at the request of Dr. Muenzinger and Miss Reynolds, was primarily for the purpose of checking results obtained in the Colorado Laboratory. These results are reported by Muenzinger and Reynolds (3) in this journal.

With the exception of Walton (6), whose findings are regarded as equivocal (3, 5), no previous investigator has obtained evidence that rats can discriminate red in terms of its wave-length properties. In general the method of previous workers (1, 4, 5, 6) has been as follows: The rats were trained to discriminate between a red and a colorless area. Then the intensity of the colorless area was varied through a rather wide range. Under these circumstances discrimination failed when the brightness of the colorless area approximated that of dark gray or black, depending upon the brightness of the red. However, as the senior writer has pointed out elsewhere (4), there is a chance that the rat, when confronted by stimuli of different brightness as well as color, may respond to brightness (easily discriminable by the rat) and not to color as such, even though color discrimination is possible. If the animals were responding upon the basis of a brightness difference from the beginning it is not likely that they would be able to transfer immediately to color when the brightness difference was eliminated.

Muenzinger and Reynolds (3) met this difficulty by using a method of training which is significantly different from that used by previous investigators of color vision. They avoided the possibility of setting up a simple brightness discrimination by requiring the rats to discriminate a red area from either a white or black area with which it was paired in alternate series of trials. The red area was paired with the white area for ten trials and then with the black area for

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a further series of ten trials This was repeated until the animals were discriminating the red area from either the black or white areas with a high degree of accuracy Such a procedure rendered impossible a response to the red area as *brighter or darker than* the colorless one. When the intensity of the colorless area was varied in ten steps from white to black the animals continued to discriminate. At only one step, that just before black, did the accuracy fall significantly below 100 per cent. At this step the accuracy was 80 per cent, too high to be accounted for by chance factors. The rats were apparently responding to the red area without depending upon its brightness in relation to the steps in the white-black continuum

The present investigation involves a check on the results of Muenzinger and Reynolds We used a somewhat different apparatus, a different intensity of red, more steps in the controls of brightness, and a number of additional controls. Some of the rats were sent to us by Muenzinger and Reynolds after they had finished experimenting with them. Others were obtained from local stock.[1]

APPARATUS, SUBJECTS, AND METHOD

The apparatus was a modification of one used previously by the senior author (5). The light box was identical with the one previously used However, the discrimination box, which is illustrated in Figure 1, differed from the previous apparatus in certain important respects. The areas to be discriminated were in a vertical position at the end of the discrimination chamber rather than on the floor, and the doors leading to the food platform were on the outer sides of the chamber rather than in the direct path of the rat.

The apparatus was constructed of three-ply wood. It was 18 inches deep at its farther end All partitions extended the full height of the box Other important dimensions are shown in the illustration Black velvet was used to line the interior of the discrimination box in order that reflection from the floor and walls would be minimized. Since we wished to have the entire floor, as well as the walls, covered with velvet, electric shock could not be used as punish-

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[1] Four rats were sent from Colorado, but one of these died before training was begun The Colorado rats were trained by the junior author The Pittsburgh rats were trained by the senior author, who is also responsible for this report

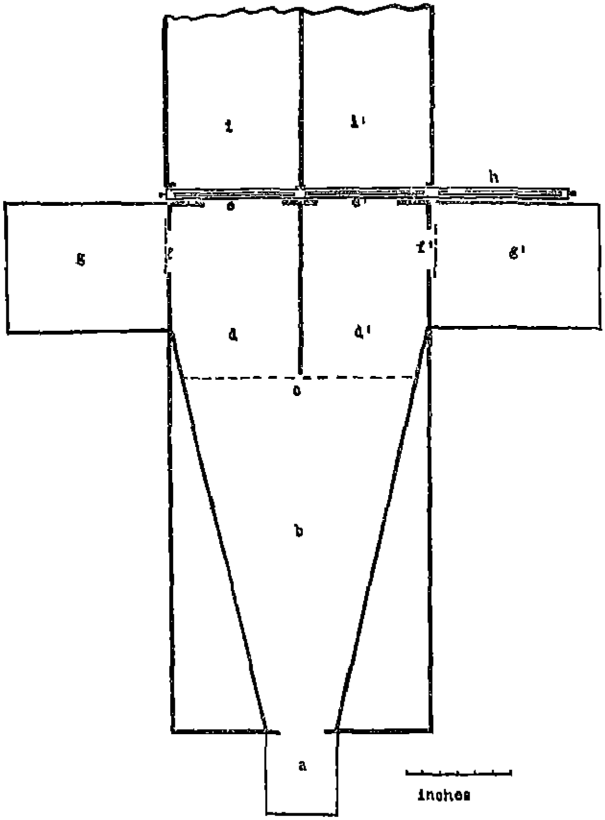

FIGURE 1

Ground Plan of Discrimination Box

The entrance box, containing the rat, was placed on the entrance platform, *a* The rat ran down the ramp, *b*, inclined at 16° with the floor, toward the stimulus patches appearing vertically at *e* In approaching the stimulus patches it ran into the chamber, *d*, or *d'* When the chamber entered was that containing the red area the door, *f*, or *f'*, at the side of the chamber opened to admit the rat to the food platform, *g* The animal was returned from this platform to the entrance platform by means of the entrance box When the rat entered the chamber containing the colorless area the door, *c*, which was lowered from above, confined it to this chamber until it was removed by the experimenter. The rat was transferred by hand from the incorrect stimulus chamber to the entrance box The filter carrier, *h*, *served to change the filters from side to side in a chance order.* Usually the red filter (Wratten No 29*f*) was in the center of the carrier with a neutral filter (milk glass) on each side of it The light box, *i*, consisted of two chambers each of which contained a 60-watt Mazda daylight lamp (matched in intensity by means of a Macbeth Illuminometer) The lamps could independently be moved to variable distances from the stimulus patches. Light from the light box could enter the discrimination box only through the filters and 25-square-inch windows of milk glass, one of which appeared on each side of the central partition The entire inside of the discrimination box was lined with black velvet. The top of the discrimination chamber from *c* to *h* was covered by a sheet of black cardboard All doors were manipulated from the front of the apparatus by means of cords

ment for incorrect responses. Door *c* was closed behind the rat after an incorrect response, thus confining the animal to the incorrect chamber Door *c* was also used at times in order to prevent retracing. During the later stages of the experiment, however, its sole use was for confining the animal after an incorrect response. The doors were never operated while the animal was making its discrimination

The 60-watt Mazda daylight lamps used as sources of illumination were located 29 inches from the stimulus patches. They were at this distance for both the red and colorless areas In some parts of the experiment, as indicated later, the distance of the lamps from the stimulus patches was varied

Two openings five inches square were cut in the end of the discrimination chamber, one on each side of the central partition. Each aperture thus formed was covered with a sheet of milk glass ⅛ of an inch thick No light could enter the discrimination chamber except that transmitted by the filters and these 25-square-inch milk glass windows. Red light was obtained by inserting Wratten filter No 29*f* in the filter carrier between the 60-watt lamp and the *milk-glass* window patch The gelatin filter was between two sheets of ordinary glass. White light was obtained by placing a piece of milk glass in the filter carrier This milk glass had a thickness of ⅛ of an inch. As measured with a Macbeth Illuminometer, the illumination of the white area inside the discrimination chamber was approximately .512 apparent foot candles To obtain a black area, one of the 60-watt lamps was turned off In addition, to prevent entrance of any light from the lighted half of the light box, a sheet of black cardboard was inserted between the light chamber and the discrimination box on the side involved. Throughout the major part of the controls the intensity of the red and the colorless areas was varied by the insertion of sheets of Republic Bond and wax paper (having, respectively, reducing values of approximately 40 and 8 per cent) in the filter carrier with the other filters. In some instances, as indicated later, the intensity was varied by changes in the distance of the 60-watt lamp from the stimulus patch.

The room in which the experiment was carried out adjoined classrooms and laboratories Unavoidable noises from these sources were present while the Colorado rats were being run. This may account for some of the difficulty encountered in training some of these animals and for some of the inconsistency of response during controls The rats from our own laboratory were run in the early morning before classes began During this time the room was very quiet. The windows of the room were painted black, thus making it relatively light proof

The subjects were three rats from the University of Colorado which had already been used in their experiment by Muenzinger and Reynolds, and three rats from our own laboratory All were albinos. Our rats were between two and three months old at the beginning of the experiment. Food consisted of two pieces of Purina Dog Chow daily and a few pieces of lettuce once a week.

After a preliminary period of adaptation to the apparatus and general procedure the rats were required to discriminate the red area from the white and black areas Ten trials were given with red versus white, the animals being required to select the red area These trials were followed, after an interval of a few minutes, by ten trials with the red versus the black area, the animals again being required to select the red area. The order of presentation of the red versus the white and the red versus the black combinations was reversed from time to time In all, twenty trials were given daily, ten on each combination. After a correct response, which comprised running into the chamber containing the red areas as far as the rat's body length, the animal was admitted to the food platform where a piece of Dog Chow was available. After an incorrect response, which consisted in entering the chamber containing the colorless area as far as its body length, the rat was confined for several seconds The door to the food platform was not opened and the animal was removed from the chamber by hand Usually, when thus confined, the rat attacked the door to the food platform

Precautions against the use of extraneous cues were carefully controlled from the beginning Additional controls were carried out at appropriate times during the experiment At all times the experimenter was hidden from the animal's view, the doors were operated only after the discrimination had been made, food appeared on both food platforms, the animal was conveyed from the food platform or the confinement chamber to the entrance of the discrimination box by means of a box, the box was placed against the entrance in a uniform manner, both lamps were an equal distance from the stimulus patches, the stimuli were moved from one side to the other in accordance with a prearranged random schedule, and the filter carrier was moved at each trial whether the position of the stimuli was to be changed or not. Additional controls instituted later in the experiment involved running the animals with all doors open, having them run by a different operator, and presenting them with stimuli alike in appearance although moved as though one were the correct stimulus In this last control there was absence of discrimination, showing that the animals had been reacting to the illuminated areas at the end of the discrimination chamber rather than to any non-visual cues.

RESULTS

Initial Discrimination of Red from Black and White Rat 4 of the Colorado group (referred to throughout this paper as Rat Col. 4) reached an accuracy of 100 per cent on the red-white combination and 98 per cent on the red-black combination within a total of 200 trials This degree of accuracy was maintained for 100 further trials before controls of brightness were carried out. Neither of the other Colorado rats attained a sufficiently high accuracy on both the red-white and the red-black combinations to make controls seem worthwhile. On the red-black combination neither animal, in a total of 400 trials, discriminated with an accuracy much greater than 70 per cent in 50 trials. On the red-white combination, however, both animals attained an accuracy of 84 per cent within the first 100 trials Their final accuracy on this combination was over 90 per cent

Two Pittsburgh rats which had received no previous training on this or other problems learned to discriminate red from white and black. Rat 1 learned to discriminate both combinations at the same time, 300 trials being required. The final accuracy was over 90 per cent in 100 trials Rat 2 learned to discriminate red from black before it learned to discriminate red from white On the red-black combination it attained an accuracy of 84 per cent in trials 200-300. However, an additional 100 trials were required before the response to the red-white combination was equally accurate. After a total of 600 trials the accuracy of discrimination, regardless of the combination involved, was 94 per cent in 100 trials

When the animals were tested with red versus either black or white on alternate trials (instead of series of 10 trials) their accuracy was 100 per cent in 10 trials each. The Pittsburgh rats were also tested with white and black paired with red in a chance manner instead of on alternate trials. This did not influence the accuracy of discrimination

The fact that these rats were discriminating red from either black or white showed that they were not responding to red as *darker or brighter* than the colorless stimuli.[2] However, the results did not offer indisputable proof of a response to red in terms of its wave-length properties Previous research by Warden and Rowley (7) has shown that ring doves trained in a manner similar to the above can respond to what is apparently absolute brightness In other words, they responded to the intermediate brightness of three stimuli just as these rats discriminated the red area from the brighter and darker areas.[3]

The behavior of our rats may have depended upon color as such or may have depended upon (1) the absolute brightness of the red, (2) the position of the brightness, or (3) avoidance of both black and white (or brightnesses greater or less than the brightness of the red). There is the possibility, also, that the rats were responding upon the basis of both absolute and relative cues To test the possibility that the animals were responding to some factor apart from color the following controls were instituted:

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[2] The question might arise here as to whether red may not have been darker than both the black and the white Subsequent controls showed that red possessed a *brightness between white and black* Our *black* was as absolute as one could produce, involving, it will be recalled from our description of apparatus, complete darkness of the stimulus compartment A size factor is of course involved here, the completely dark chamber being compared with another chamber containing a lighted area of 25 square inches However, this difference is taken care of in the controls

[3] This type of response is not confined to problems involving brightness discrimination. Warden and Winslow (8) trained ring doves to respond to the intermediate of three areas which were alike except in size. Likewise, McCulloch (2) trained white rats to pull in a 75-gram tray when it was paired, on different trials, with either a 25-gram or a 150-gram tray The response was shown to depend upon a combination of relative and absolute factors

Control 1 The intensity of the colorless area was varied from white to black, at first in 20 steps, each one of which became smaller as the black end of the continuum was approached,[4] and then in smaller steps at a region regarded as perhaps critical. As already indicated, sheets of Republic Bond and wax paper were used in effecting these variations of intensity Each sheet of Republic Bond reduced the preceding intensity by approximately 40 per cent, as measured with a Macbeth Illuminometer. Each sheet of wax paper had a reducing value of approximately 8 per cent. In the discussion of results each major variation in brightness, involving the insertion of a sheet of Republic Bond paper in the filter carrier with the milk glass, is referred to as a given step. The number of the step indicates the number of sheets of paper used to reduce the intensity of the colorless area In the case of a critical step the illumination of the area in apparent foot candles is given The results of this control are indicated in Table 1

From the table it is apparent that a rather high accuracy of discrimination was maintained throughout this brightness control All three rats showed a marked degree of hesitation in the vicinity of Step 6 (.020 apparent f c.). On Step 6 the Colorado rat at first failed to discriminate, but it improved during a total of 90 trials on this step so that its average accuracy for these trials was 87 per cent. Rat 2 also seemed to be disturbed at this point, making three errors in the first 10 trials The next 10 trials were correct. Rat 1 made no errors at this step, although more than usual hesitation was apparent at this and immediately preceding and following steps The Colorado rat had difficulty in discriminating at Steps 10 and 11 Rat 2 also made more than the usual number of errors at Step 10. For no rat, however, did the accuracy at this step fall below 80 per cent in 20 trials

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[4] Smaller steps at the black end were thought desirable since previous research (1, 4, 5, 9) had shown red to have low stimulating value for the rat's eye, being equivalent to dark gray or black.

TABLE 1

CONTROLS INVOLVING VARIATIONS IN THE INTENSITY OF THE COLORLESS AREA

Intensity values in steps	Accuracy of discrimination in percentage*		
	Rat Col 4	Rat 1	Rat 2
1	95(20)	100(10)	90(10)
2	100(20)	100(10)	90(10)
3	90(30)	100(10)	100(10)
4	88(35)	90(10)	100(10)
5	87(40)	100(10)	90(10)
6	87(90)	100(10)	85(20)
7	87(30)	90(10)	90(20)
8	87(46)	100(10)	100(10)
9	86(86)	90(10)	90(20)
10	87(81)	90(20)	80(20)
11	87(92)	100(10)	90(10)
12	95(21)	90(10)	100(10)
13	94(15)	90(10)	100(10)
14	100(15)	100(10)	100(10)
15	87(15)	100(10)	100(10)
16	*100(15)*	*90(20)*	*100(10)*
17	100(15)	100(10)	100(10)
18	100(15)	100(10)	100(10)
19	100(15)	100(10)	100(10)
20	100(15)	100(10)	100(10)

*Figures in parentheses indicate the total number of trials given at this step, including retraining trials

The controls were repeated with Rat 1, but working from the black to the white end of the continuum The results did not differ significantly from those shown for this rat in Table 1.

Step 6, as indicated above, presented unusual difficulty at first, although all three rats finally discriminated with a high degree of accuracy. This step was relatively dark, its illumination being approximately .020 apparent foot candles. Step 7 had an illumination of approximately .012 apparent foot candles The following steps were too dark to be measured by means of the Macbeth Illuminometer or any other available instrument.

We wondered if, and at what step, rats *trained to discriminate red from white* (in accordance with the method of previous investigators) would fail to discriminate when subjected to the above controls. One previously untrained rat, to which we shall refer as Rat 3, was given 300 trials on red versus white, its final accuracy being 90 per cent in 30 trials. One of the Colorado rats (Rat 1) which had failed to discriminate red from white and from black when trained some time before, was now similarly trained on red versus white. Its accuracy of discrimination in the last 50 of 100 trials was 94 per cent. When they were subjected to the controls discussed above both rats reached a point where discrimination was apparently impossible Rat 3 discriminated red from Steps 1 to 6 with an accuracy close to 90 per cent. On Step 7, however, its accuracy fell to 59 per cent in 80 trials. In the last of these 80 trials the accuracy was just as poor as in the beginning. When red was lowered in intensity by approximately 40 per cent the accuracy with which it was discriminated from Step 7 increased to 85 per cent in 20 trials. When the red was returned to normal intensity the accuracy again dropped to approximately 50 per cent. Training was discontinued at this point. A month later, however, this rat was trained again in exactly the same manner as just discussed. This time, to our surprise, it discriminated red from all of the steps from 1 to 20 Initially Step 11 appeared to give some difficulty, but the final accuracy at this step was 90 per cent in 20 trials. The Colorado rat trained to discriminate red from white failed to discriminate when Step 6 was reached Its accuracy at this step was 68 per cent in 60 trials with no improvement evident at the end of these trials. When tested at Step 7 its accuracy was 45 per cent in 20 trials. At Step 8 it discriminated with an accuracy of 50 per cent in 10 trials. At Step 9 its response was reversed It went to the colorless instead of to the red area on each of 10 trials Apparently this animal was responding to red as *darker than* the colorless area until Step 6 was reached At Steps 6-8 the colorless area and the red area were apparently of approximately equal brightness At Step 9, however, the colorless area was apparently the darker one. The animal responded to it as it had formerly responded to the red area.

These results are interesting in the light of the fact that steps in the vicinity of 6 and of 10 appeared to offer unusual difficulty to rats trained to discriminate red from either black or white. Since the steps in the neighborhood of 6 were relatively large, and perhaps a crucial brightness appeared between them, we subdivided Steps 6 to 8 into ten further steps Sheets of wax paper, each of which had a reducing value of approximately 8 per cent, were used with the sheets of Republic Bond. In reducing value, five of these sheets roughly equaled one sheet of Republic Bond. The four rats which had maintained their discrimination throughout the preceding controls were given from 10 to 20 trials at each of these 10 substeps The average accuracy for *each rat on all such steps did not fall below* 90 per cent The lowest accuracy at any step was 85 per cent in 20 trials

If these animals were responding upon the basis of the brightness value of the red area, either absolutely or in relation to brightnesses in the white-black continuum, it appears that they should have failed to discriminate at some step in the range tested Likewise, if they were responding negatively to white and to black (or to brightnesses greater and less than that of the red), the animals should have been confused by these controls of brightness Although considerable hesitation was apparent at some steps, the accuracy of discrimination throughout was significantly greater than could be attributed to any chance factors

Although these controls gave results which amply verified the findings of Muenzinger and Reynolds (3), it was decided that some further controls might throw additional light upon the nature of the discrimination.

Control 2. The intensity of the red area was varied through a wide range while the intensity of the colorless area was held constant at what appeared, from the previous results, to be a critical step. Steps 6 and 7 were tested in this way, using the Pittsburgh rats, 1 and 2. *Discrimination was maintained at a high accuracy except* when the red light was very dim (reduced by means of five sheets of Republic Bond) With this low intensity of red the accuracy was 70 per cent while with all higher intensities it was from 80 to 100 per cent At the lowest intensity, however, red was very poorly saturated and this low saturation, rather than the intensity as such, may account for the decreased accuracy of discrimination The very high intensities of red, all of which were discriminated with an accuracy of over 90 per cent, were produced by moving the 60-watt lamp closer to the stimulus patch.

If the animals were responding to red as to an absolute or as to an intermediate brightness they should have failed to discriminate when its intensity was markedly changed; that is, *unless all intensities of red had such a low brightness value for the rat's eye as to make changes indiscriminable.* That at least one of our changes in the intensity of red was discriminable to the rat's eye is suggested by results with Rat 3 already discussed under Control 1 It will be recalled that Rat 3, before it finally learned to respond to red at all intensities of the colorless area, failed to discriminate the red (at the intensity used during training) from Step 7. Its accuracy at Step 7 was 59 per cent But when the intensity of the red was reduced about 40 per cent, the animal's accuracy increased to 85 per cent The accuracy dropped to 50 per cent when the red was returned to the previous intensity

Control 3. The red was presented with a different intensity of colorless light at each trial, the intensity to be paired with it on any given trial being selected in a random fashion While the intensities used from time to time covered the range from Steps 1 to 20, most of them were selected from the middle range (5-15) since it was within this region that apparently critical intensities were located In a somewhat similar manner a given intensity of the colorless area, selected from the middle region of intensities, was paired with a different intensity of red at each trial On none of these controls did the accuracy of any rat fall below 80 per cent. In most of them the accuracy ranged from 90 to 100 per cent

Here again, if the animals were reacting to red as to a given absolute or relative brightness value, or reacting negatively to brightnesses greater or less than that of the red, discrimination should have seriously been disturbed The fact that a high degree of accuracy was maintained on this and preceding controls lends strong support to the conclusion that the rats were responding to red in terms of its wave-length properties However, a further control which seems to offer conclusive evidence that brightness was not a factor in the discrimination was instituted

Control 4 During this control a different intensity of red was paired with a different intensity of colorless light at each trial, the combinations being made up in a random fashion Most of the intensities were from the middle of the range although we used some from each end This control really involves a combination of controls 2 and 3 Under these conditions *the only constant factor which the animals might discriminate was the wave-length property (or properties) of the red light* It is inconceivable that the rat could maintain its discrimination throughout this control if it were respond ing to any kind of brightness cue. The Colorado rat discriminated with an accuracy of 96 per cent in 50 trials, Rat 1 with an accuracy of 90 per cent in 30 trials, Rat 2 with an accuracy of 100 per cent in 20 trials, and Rat 3 with an accuracy of 95 per cent in 20 trials.

Although these results demonstrated that the animals were responding to wave-length rather than to brightness, they did not indicate whether the response was to *red* or whether it was to some *more general* property associated with any relatively monochromatic light as compared with an achromatic one

That the red light may have possessed some property other than its *redness,* so to speak, was apparent when an adult, shown by the Ishihara test to be red-green blind, discriminated the red area from each of 20 intensities of the colorless area These intensities were those used in Control 1. The subject reported that the red area possessed a "distinctly different quality" which enabled him to differentiate.[5]

The fact that a red-green blind human subject differentiated between the red area and all of the intensities of the colorless area suggested that a further control might prove enlightening

Control 5. If the red light possessed some "quality" other than its *redness,* let us say, perhaps green, blue and yellow lights would possess similar "qualities," these being a function of their relatively monochromatic nature rather than of their precise wave-length. In such an event the rat, when presented with white and green, blue or yellow light should respond to these colors as equivalent with red.[6]

To test this possibility two of the Pittsburgh rats were presented with white and, respectively, a different red from that used during training (Wratten filter No. 70 substituted for Wratten filter No 29*f*), green (Wratten filter No. 74), blue (Wratten filter No. 75) and yellow (Wratten filter No 73). The intensity of white was that used in original training. The position of the lamp behind the colored filters was likewise that used during training with red. Only a relatively small number of trials could be used in each test, since we did not wish to train the animals to make the new discriminations For the same reason all responses were rewarded

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[5] One should perhaps emphasize the fact that any difference in the "quality" of the two areas must reside in properties of the respective lights and not in the surfaces on which these were projected and which served to transmit them Both sheets of milk glass were cut from the same piece Even this was not necessary, since the red light was transmitted by one just as frequently as by the other With a low intensity of red, the human subject had some difficulty At this same intensity, however, the rats discriminated with an accuracy of 100 per cent

[6] The same results would also occur if the animal were responding negatively to white; but the previous controls had shown that the response was positively to the red area

Both rats maintained an accuracy of over 90 per cent when the new red was substituted for the red of original training For Rat 1 green was apparently equivalent with red, since the animal selected green 18 times in 20 trials. This animal also responded to yellow 8 times out of 10. Rat 3 showed no marked preference for either of these colored areas, selecting each 6 times out of 10. Neither rat showed a preference for blue. These results seem to indicate, then, that for one rat green and yellow were equivalent with red in stimulating value However, when red and green were presented together for 10 trials, this rat went every time to the red. Hence the red and green areas could not have been *identical* in stimulating value[7] Two other rats also discriminated red from green. Rat 2 had an accuracy of 90 per cent in 10 trials and Rat 3 an accuracy of 100 per cent in 10 trials. When red was paired with yellow, Rat 1 failed to discriminate, while both of the other rats went with an accuracy of 80 per cent to the red When red was paired with blue the accuracy of Rat 1 was 90 per cent in 10 trials, the accuracy of Rat 2 was 73 per cent in 15 trials, and the accuracy of Rat 3 was 100 per cent in 10 trials Hence two of the animals were apparently discriminating between the red and blue areas[8] When red was paired with yellow, the accuracy manifested by Rat 1 was 60 per cent, while that manifested by Rats 2 and 3 was 80 per cent Ten trials were given each rat.

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[7] Of course they were probably different in brightness value for the rat's eye, but previous controls had shown that the animals were not reacting on the basis of any brightness factor

[8] We hesitate to say that the animals were discriminating between *red* and *blue*, as such, because the colors were not equated in brightness value for the rat's eye This is also true of the other color combinations In the light of the fact, however, that controls had shown the animals not to be discriminating brightness differences there is a strong suggestion that actual color discrimination was present Experiments conducted along lines similar to those suggested in a preceding article (5) should prove whether or not this suggestion is correct Walton (6) obtained discrimination between red and, respectively, green, blue, and yellow, but the colors were not equated in brightness for the rat's eye, hence his results, like those above, are equivocal as evidence for red-green, red-blue, and red-yellow discrimination

Although the results of this control are somewhat inconsistent from rat to rat and from one color combination to another, it appears that the red area was being discriminated in terms of its peculiar wave-length instead of in terms of some more general property which might appear in any relatively monochromatic light If the animals were responding to the red area in terms of some "quality" characteristic of *any* relatively monochromatic light they should have failed to differentiate it from other relatively monochromatic lights

SUMMARY AND CONCLUSIONS

In this investigation, which was undertaken to check results obtained previously by Muenzinger and Reynolds (3), white rats were trained to discriminate between red light and both white light and darkness Red was paired with white and with darkness on alternate sets of trials. After the rats were selecting red with a high degree of accuracy, regardless of whether it was paired with white light or darkness, several controls involving variation in the intensity of the red and colorless lights were carried out. These controls showed that the discrimination was not dependent upon the absolute or relative brightness value of the red light and that the rats were not responding negatively to white and black, or to brightness greater and less than that of the red light It appeared that their response was to some property of the red light apart from its brightness value Further controls in which red was paired with other relatively monochromatic lights showed that the rats were responding to some property peculiar to *red* rather than to a property which might be present in any relatively monochromatic light in comparison with an achromatic one

These results amply verify those of Muenzinger and Reynolds.

The discrepancy between the results obtained by Muenzinger and Reynolds and the results of previous investigators is probably due to a difference in training methods The present method prevented the animals from responding to the colored light as *darker or brighter than* the light with which it was paired.

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A STUDY OF A SOCIAL HIERARCHY IN THE LIZARD, *ANOLIS CAROLINENSIS*[*]

From the Biological Laboratories of Harvard University

LLEWELLYN THOMAS EVANS

It is doubtful if a better species of lizard could be chosen for studies of dominance than *Anolis carolinensis*. It is a very hardy animal, lives well in captivity, and the males fight frequently during the sunny days of spring, summer, and fall. It is the latter fact which made this study possible.[1]

Dominance has been reported in a few cases among lizards. Zapf (10) describes the dominance of one male over other males of the same species of Lacerta in the same cage Noble and Bradley (6) in a splendid monograph on lizard mating behavior describe the same phenomenon among captive *Anolis* but they state that it occurs but rarely. Fighting and dominance (Evans, 1, 2, 3) occurred during the winter months among *Anolis carolinensis* which were stimulated by injections of sheep pituitary extract (Parke Davis) and of human pregnancy urine extract (Parke Davis). If a male that was dominating a cage was removed, a second male soon established himself in the rôle of dominance, but only after fighting and defeating other challenging males Control males did not respond in this way during mid-winter. Because of this observed dominance the present study was carried out on normal males of *Anolis carolinensis* to discover whether true social hierarchies occur among captive *Anolis* or can be established by experimental means.

Before describing the material and the very simple technique used, it would be well to call attention to certain details in the social behavior of lizards in general and *Anolis* in particular.

Noble and Bradley (6) list 23 species of lizards of which the males are known to fight. And since a complete bibliography of the subject is included in their paper it is only necessary to refer to it here.

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[*] Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office, June 24, 1935

[1] I wish to thank Professors T Barbour, A B Dawson, G Pincus, and W M Wheeler of Harvard University for their very kind aid and interest in connection with this problem

It is thus obvious that fighting is a common phenomenon among lizards However, this activity seems to be induced, for the most part, by the urge of males to defend particular and restricted territories against other males (Noble and Bradley, 6, Wiedemann, 9) If a wandering male, *A*, should chance to linger in the chosen territory of male *B*, a fight ensues, the outcome of which will decide which of these two will hold the territory If a female approaches, her response to the male ordinarily is passive so she is permitted to remain

A full description of the fighting and mating behavior of *Anolis* has been given by Noble and Bradley (6). It is only necessary to mention here that in both sexes a dewlap or fan beneath the lower jaw may be extended by the forward movement of a pair of slender bones beneath the loose skin In males this extended dewlap measures about 3 cm across, but only approximately 0 8 cm on females It is red in males, becoming a brilliant scarlet when the direct rays of the sun strike it. The body can be flattened laterally when the animals are enraged Even females flatten the body in this way, as was observed among castrates Incidentally, castrated females were observed to fight exactly as the males do. Normal females rarely fight Males possess a crest along the nape of the neck and back which rises to a height of 3½ mm. during fighting activity

The stages which ordinarily occur in fighting are· (1) Both males move slowly toward each other while each animal raises its crest and flashes its dewlap (not usually to its fullest extent, at first, however). The body is flattened and the animals move sidewise toward each other One, usually the resident male, slowly turns green This stage is apparently an attempt to impress or frighten. (2) If, after repeated circling, strutting, and display of dewlap neither gives way, they come closer, each attempting to get a position higher than the other. Soon they turn their heads toward each other, their mouths open wide, and with jaws less than a centimeter apart each attempts to bite the snout of the other No actual biting occurs for several seconds, but they thrust and withdraw their jaws repeatedly until one secures the desired hold on the other's snout. This may end the fight But a persistent challenger will return to snap and bite two or three times. However, the one that secures the first jaw-hold usually wins (3) The defeated male is chased away and the victor takes a prominent position at the top of the cage, flashes his dewlap to its fullest extent, and struts back and forth with body flattened. Later, he may pursue the defeated male again (4) The dominant male usually takes no further notice of the other unless the latter attempts to approach. A flash of the dewlap is enough to frighten the victim away

It should be particularly emphasized that not a single vocal sound is uttered by either animal during the fight. Often, the only sounds to be heard are those produced by the click of teeth when the jaws of the two combatants come together, or the rustling of leaves as the defeated male retreats This silent mode of fighting seems to be characteristic of the great majority of diurnal lizards In contrast, the nocturnal lizards, or geckos, do not utilize bright colors or special structures as a means of frightening rivals, but fight desperately, frequently to the death Geckos have well developed vocal powers and constantly utter chirps or squeaks in a considerable range of pitch, especially during courtship and fighting.

MATERIALS AND TECHNIQUES

Nineteen males of *Anolis carolinensis* were used in the experiments. They ranged in weight from 3.9 grams to 7.5 grams. All but male *A* were sent from Louisiana in February, 1935. *A* had been kept in the laboratory since February, 1934 Figure 1 shows the males used in this study

The six cages, each two feet high and 18 inches square, were covered with bronze screening and were arranged in two tiers of three each in a large window with a southern exposure The floor of each cage was covered with sand and gravel. Branches, bits of bark, and leaf debris were scattered in each cage.

The animals were watered by sprinkling the cages twice daily. They were fed daily with adult flesh flies, Tenebrio larvae, and occasionally with spiders.

Three large aquarium tanks filled with water together with the sprinkling of the cages seemed to produce enough humidity to keep the animals in good condition. The temperature ranged from 70 to 80 degrees Fahrenheit

The experiments extended from March 7 to May 13, 1935

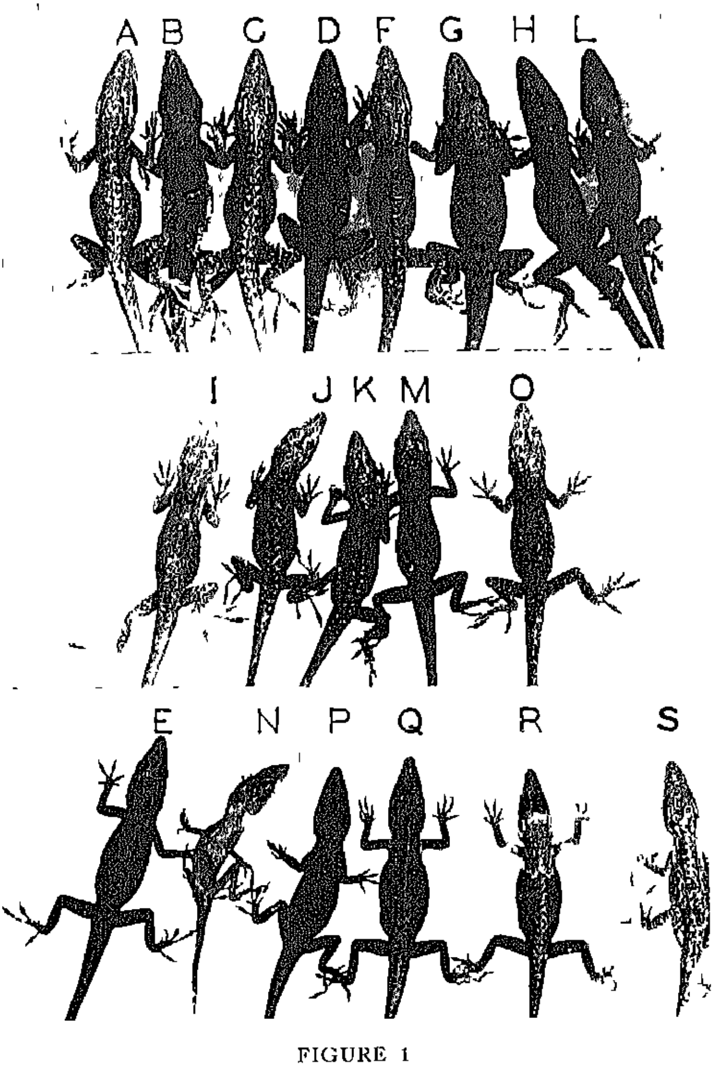

FIGURE 1
THE NINETEEN MALES USED IN THE EXPERIMENT
Top row Categories I and II, middle row Category III, bottom row Category IV

The technique was as follows With all 19 males in the first cage they were watched until one male had definitely become dominant by defeating all others who challenged him This male was immediately caught, weighed, and marked by clipping oft the distal end of a particular toe (Suctorial pads on each toe supplement the claws so that the loss of one or two claws does not handicap the animal.) He was then placed in Cage 2, and was registered as male *A*. The second male to become dominant was registered as *B*, the third as *C*, and so with all 19 animals. As soon as two or more were placed in Cage 2, fights occurred, establishing dominance in that cage The dominant male of Cage 2 was then placed in Cage 3 Thus, it continued until all of the six cages had been occupied by each of the 19 animals in turn (with a few exceptions which will be discussed later).

Cage 3 contained, besides the male *Anolis*, several castrated female *Anolis* and a variable number of *Sceloperus undulatus* of both sexes Cage 4 contained, in addition to the male *Anolis*, three geckos (*Gymnodactylus kotschyi*), while Cage 5 also contained three geckos (*Hemidactylus turcicus*) These geckos, Sceloperus, and castrated females in no way destroyed the dominance pattern. The customary fights took place in each cage regardless of the other species present. The rivals often crawled over the Sceloperus in Cage 3 while going through their fighting maneuvers. When this happened, no notice was taken of the Sceloperus In fact, a male in combat never took his eyes oft his opponent for an instant When shifting his position he pushed one leg out, groping for a foothold, then slowly extended the other, feeling his way along

Each cage was numbered, from one to six The following, Table I, shows the rank of each male in each cage together with the date and hour when each male became dominant

Table 2 shows the weight of each animal when he was marked and registered after becoming dominant for the first time, and the weight of each again, May 8, a few days before the experiment was concluded In Table 3, nine witnesses are recorded with the date of the particular combat observed, the victorious male, and the cage number.

Because of the difficulty of photographing the males in action without altering the conditions of the experiment, I felt it was im-

TABLE 1

THE DATE OF DOMINANCE OF EACH MALE IN EACH CAGE

Cage 1		
A	March 7	
B	March 9	10:30 a.m.
C	March 16	2:00 p.m.
D	March 19	3:00 p.m.
E	March 20	1:30 p.m.
F	March 22	a.m.
G	March 25	12:00
H	March 27	3:00 p.m.
I	March 27	3:30 p.m.
J	March 28	a.m.
K	March 29	11:00 a.m.
L	March 29	11:30 a.m.
M	March 30	11:00 a.m.
N	April 3	10:20 a.m.

Cage 2		
A	March 20	1:30 p.m.
B	March 21	10:00 a.m.
C	March 22	10:40 a.m.
F	March 30	11:30 a.m.
D	March 31	12:15 p.m.
G	March 31	1:30 p.m.
H	April 3	10:15 a.m.
J	April 3	10:30 a.m.
I	April 3	11:00 a.m.
K	April 4	11:00 a.m.
M	April 5	10:40 a.m.
L	April 6	12:00 a.m.
O	April 14	11:30 a.m.
N	April 16	12:30 p.m.
P	April 18	10:10 a.m.
Q	April 20	9:00 a.m.
R	April 25	10:20 a.m.
S	April 28	12:00 a.m.
E	April 30	11:00 a.m.

Cage 3		
A	March 29	1:30 p.m.
B	March 31	12:10 p.m.
C	April 3	9:15 a.m.
D	April 3	11:10 a.m.
F	April 4	10:30 a.m.
G	April 4	11:30 a.m.
H	April 6	9:45 a.m.
L	April 11	8:30 a.m.
I	April 11	8:55 a.m.
J	April 11	9:00 a.m.
M	April 11	9:40 a.m.
O	April 15	11:00 a.m.
K	April 18	10:20 a.m.
Q	April 20	9:45 a.m.
R	April 25	10:40 a.m.
P	April 25	3:40 p.m.
E	May 5	11:45 a.m.

Cage 4		
A	March 31	11:00 a.m.
B	April 3	11:25 a.m.
C	April 4	11:00 a.m.
D	April 4	11:30 a.m.
F	April 5	1:00 p.m.
G	April 6	10:00 a.m.
H	April 11	8:40 a.m.
L	April 14	11:45 a.m.
J	April 14	11:55 a.m.
O	April 15	11:15 a.m.
I	April 16	10:00 a.m.
K	April 18	10:25 a.m.
Q	April 20	10:00 a.m.
M	April 25	10:45 a.m.
P	April 28	12:25 p.m.
E	May 5	8:50 a.m.
R	May 9	10:30 a.m.

Cage 5		
A	April 3	11:20 a.m.
B	April 4	11:00 a.m.
H	April 11	8:55 a.m.
C	April 14	12:15 p.m.
D	April 15	10:30 a.m.
G	April 15	12:00
L	April 16	1:00 p.m.
F	April 18	10:40 a.m.
J	April 18	10:50 a.m.
Q	April 20	10:45 a.m.
I	April 22	9:50 a.m.
K	April 23	10:20 a.m.
M	April 26	9:40 a.m.
P	May 1	3:40 p.m.
E	May 9	10:33 a.m.

Cage 6		
A	April 11	12:00
B	April 14	12:15 p.m.
H	April 15	11:00 a.m.
D	April 16	10:15 a.m.
C	April 18	9:15 a.m.
E	April 18	10:58 a.m.
L	April 18	1:05 p.m.
G	April 18	1:05 p.m.
Q	April 22	10:15 a.m.
J	April 22	10:15 a.m.
K	April 25	9:25 a.m.
I	April 26	9:55 a.m.
M	May 3	4:00 p.m.
P	May 9	11:45 a.m.
O	May 11	11:30 a.m.
E	May 13	10:00 a.m.

TABLE 2

EACH MALE IS DESIGNATED BY A LETTER IN COLUMN 1, COLUMN 2 INDICATES THE WEIGHT OF EACH WHEN HE FIRST BECAME DOMINANT; COLUMN 3 INDICATES THE WEIGHTS WHEN THEY BECAME DOMINANT IN CAGE 6

A	7.5	6.4
B	6.8	7.5
C	5.8	6.0
D	6.3	6.0
E	5.0	5.3
F	5.5	5.5
G	6.1	6.2
H	6.3	6.5
I	5.1	5.6
J	4.5	4.5
K	4.7	4.5
L	4.7	4.9
M	5.0	4.7
N	3.9	2.25
O	5.5	6.1
P	4.7	4.6
Q	5.6	4.3
R	4.4	4.3
S	4.8	4.5

portant to have some of my colleagues at Harvard witness the combats of the males in at least a few cases. I, therefore, wish to thank the witnesses, Miss Alice Beale, Mr L. A Hansborough, Miss G. Hermes, Mr. L. H Kleinholtz, Mr. B Renshaw, Mr. G L Wood-

TABLE 3

WITNESSES

Hansborough, L A	Cage 2 Animal *H*	April 3
Kleinholtz, L H.	Cage 2 Animal *K*	April 4
Woodside, G L	Cage 5 Animal *H*	April 11
Kleinholtz, L H.	Cage 5 Animal *C*	April 15
Renshaw, B.	Cage 5 Animal *G*	April 15
Hoadley, L Hermes, G.	Cage 6 Animal *Q*	April 22
Beale, A	Cage 6 Animal *K*	April 26
Renshaw, B	Cage 6 Animal *I*	May 1

side, and Professor Leigh Hoadley, for their patience and interest in the problem

Because of low dominance capacity on the part of a few males, especially those designated as *E, R, S,* and *N,* only 14 males of the 19 performed in all six cages Fifteen went through the last five cages. After *N* had become dominant and was removed to Cage 2, no further fights were observed to take place to decide the supremacy of the cage among *O, P, Q, R,* and *S.* After waiting ten days these five males were placed in Cage 2. Table 1, as well as Figures 2 to 7 show that *P* and *Q* dominated at one time or another in the last five cages. *R* dominated in his turn only in Cages 2, 3, and 4, while *S* only dominated in Cage 2 *E,* as the figures indicate, dropped down the scale from fifth place in Cage 1 to the nineteenth place in Cage 2 and thereafter did not stand higher than fifteenth place in any cage *O* was dominant in Cages 2, 3, 4, and 6 None of the three males *O, R,* and *S* showed dominance in Cage 5 after several days' residence They were placed, therefore, in Cage 6.

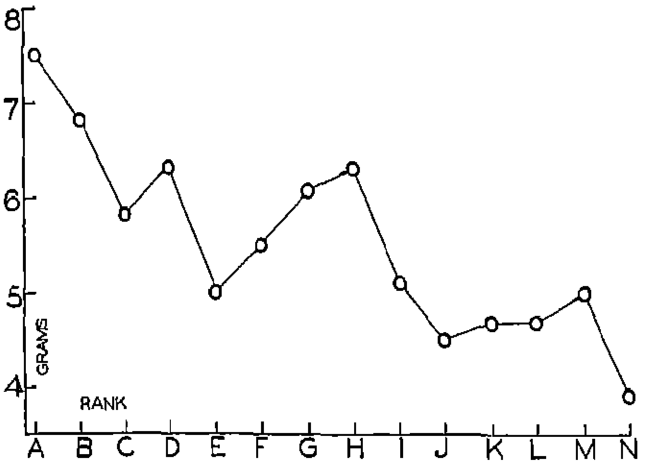

FIGURE 2
THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 1 PLOTTED AGAINST WEIGHT
Males *O, P, Q, R,* and *S* failed to dominate

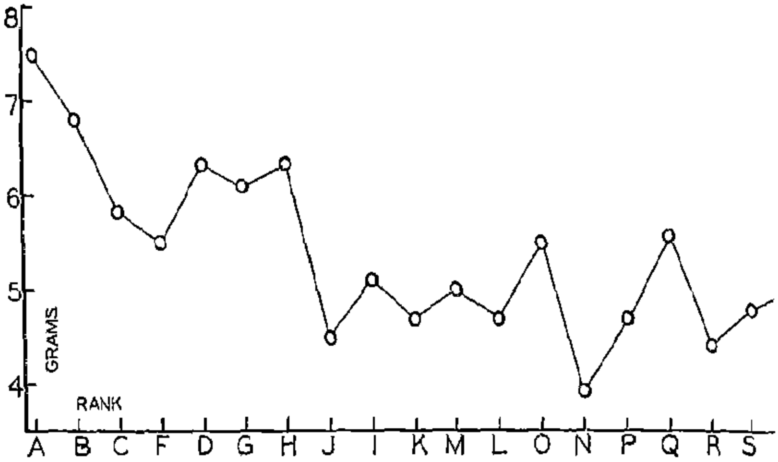

FIGURE 3

THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 2 PLOTTED AGAINST WEIGHT

Note the addition to Cage 2 of males *O*, *P*, *Q*, *R*, and *S*.

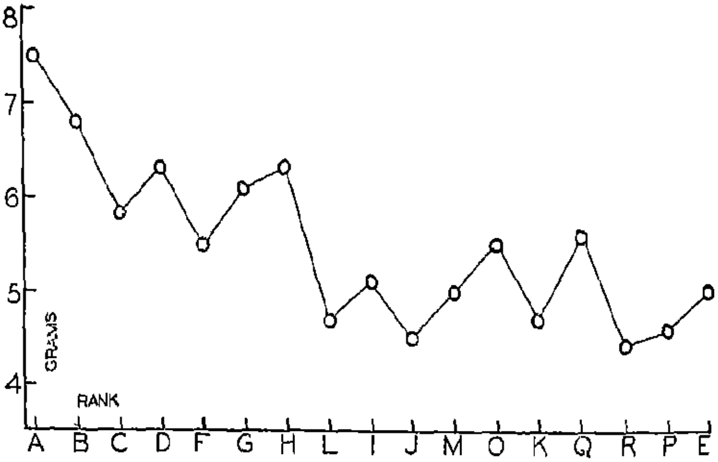

FIGURE 4

THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 3 PLOTTED AGAINST WEIGHT

Males *N* and *S* failed to dominate

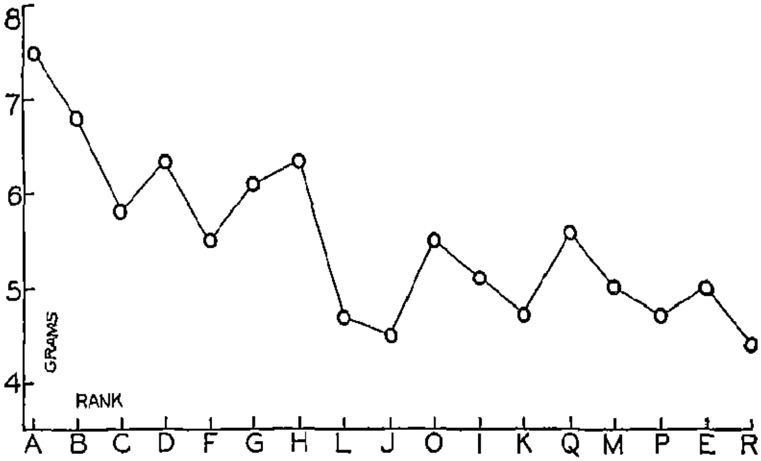

FIGURE 5

THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 4 PLOTTED AGAINST WEIGHT

Males *N* and *S* failed to dominate

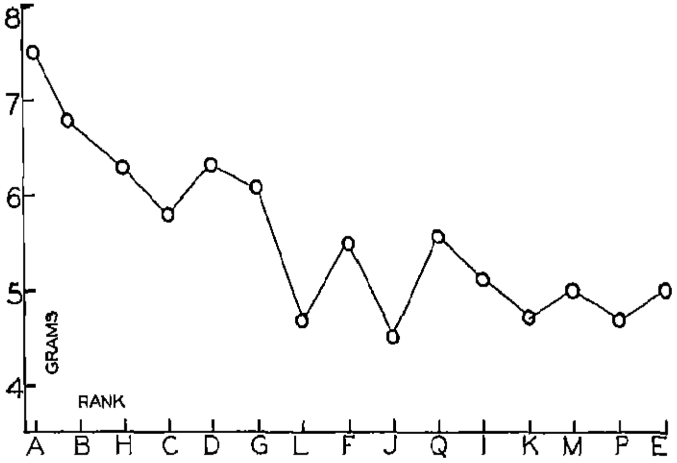

FIGURE 6

THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 5 PLOTTED AGAINST WEIGHT

Males *N*, *O*, *R*, and *S* failed to dominate

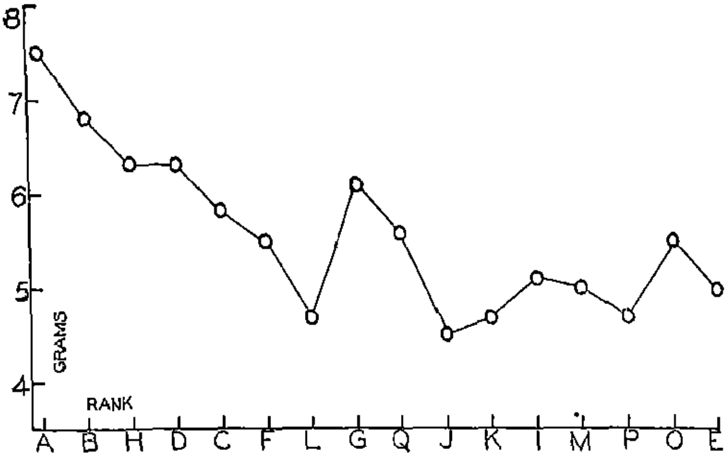

FIGURE 7

THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 6 PLOTTED AGAINST WEIGHT

Males *N*, *R*, and *S* failed to dominate

By listing the males in order of dominance horizontally, and their weight in grams vertically for each of the six cages, we have the condition shown graphically in Figures 2 to 7. In spite of considerable irregularities in these six graphs there is a marked indication that the order or scale of dominance is correlated with the weight of the males taking part. The heavier males stand at the higher end of the scale and the lighter males at the lower end.

Figure 8 gives the result of combining these six graphs into one. It shows at a glance the performance (the position held) of each male in each cage plotted against the average weight of the males which occupied each of the nineteen positions in the scale of dominance This figure indicates that dominance and weight are definitely correlated when the entire 98 combats are considered as a unit.

Closer study shows that Figure 8 is divided quite definitely into four categories:

I. Composed of animals *A, B*
II. Composed of animals *C, D, F, G, H, L*
III. Composed of animals *I, J, K, L, M, O, Q*
IV. Composed of animals *E, N, P, Q, R, S*

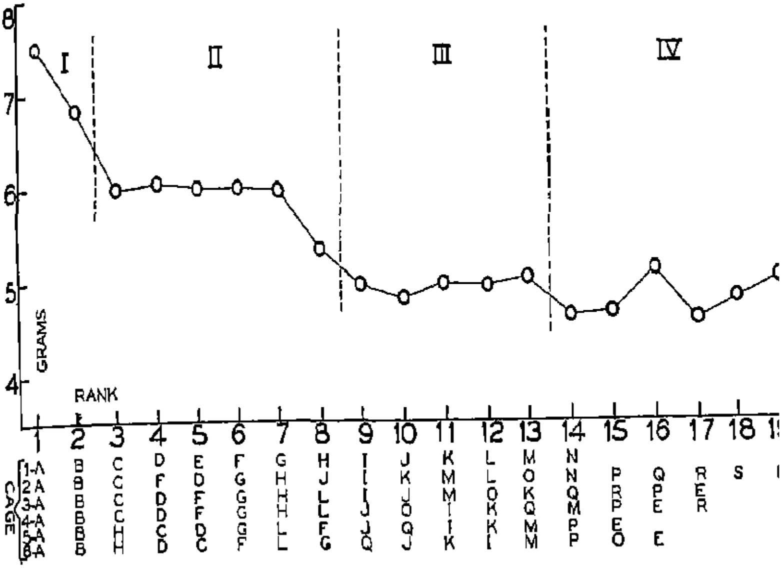

FIGURE 8

THE CLOSE CORRELATION BETWEEN ORDER OF DOMINANCE AND WEIGHT OF 19 MALES OF *Anolis carolinensis*

The 19 points on the graph were found by taking the average of the weights of the males which are listed in the vertical column beneath each point. Note that the order of dominance for each of the six cages is given if the letters are read horizontally. The four categories are labelled and show males *A*, *B*, *C*, *D*, *F*, *G*, *H*, and *L* ranked in I and II, or highest in dominance, and averaging 6.12 grams, males *I*, *J*, *K*, *M*, and *O* ranked in III, or intermediate in dominance, and averaging 4.96 grams, males *E*, *N*, *P*, *Q*, *R*, and *S* ranked in IV, or lowest in dominance, and averaging 4.73 grams.

Obviously, then, animals in categories I and II are ranked high in dominance, the animals in IV are low in dominance, while those in category III stand intermediate. A grading system was adopted to discover just how each animal stood in rank. If an animal kept the rank which he secured in the first cage throughout the entire six cages, his grade is unity. If he held his rank in five cages, but gave way to another male in Cage 6, his grade is minus one. If he held his rank unchanged in five cages, but advanced his rank three places in Cage 6, his grade is plus three. On the basis of this grading

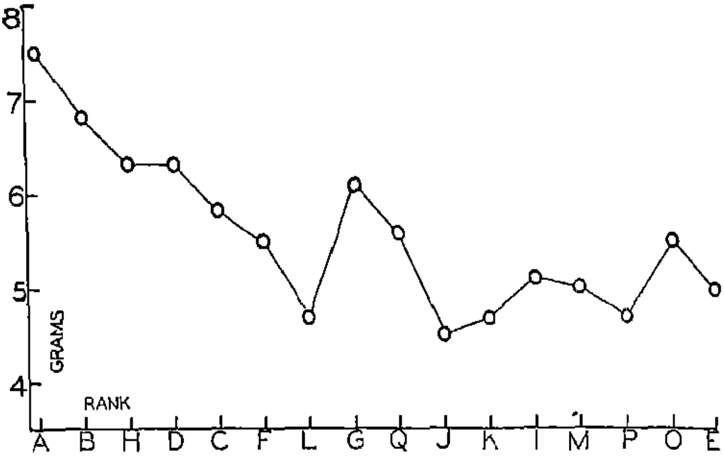

FIGURE 7

THE ORDER IN WHICH THE MALES BECAME DOMINANT IN CAGE 6 PLOTTED AGAINST WEIGHT

Males *N*, *R*, and *S* failed to dominate.

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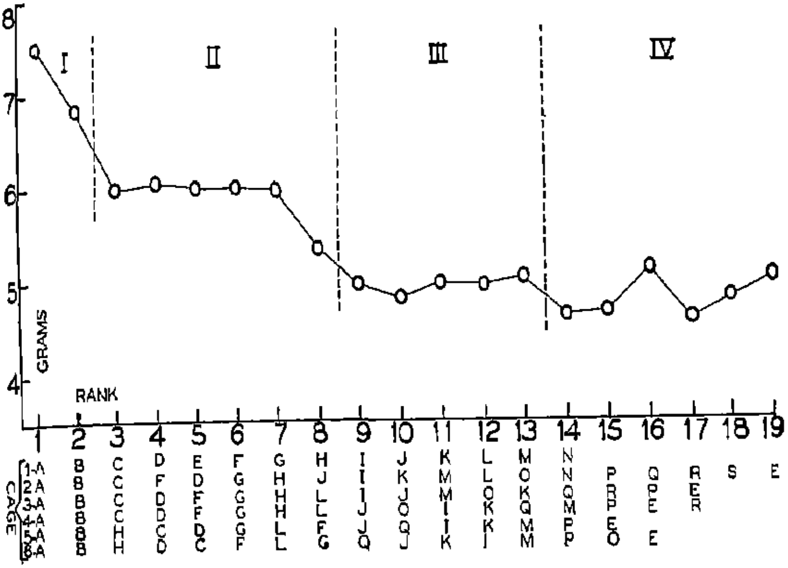
IV. Composed of animals *E, N, P, Q, R, S*



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Obviously, then, animals in categories I and II are ranked high in dominance, the animals in IV are low in dominance, while those in category III stand intermediate. A grading system was adopted to discover just how each animal stood in rank. If an animal kept the rank which he secured in the first cage throughout the entire six cages, his grade is unity. If he held his rank in five cages, but gave way to another male in Cage 6, his grade is minus one. If he held his rank unchanged in five cages, but advanced his rank three places in Cage 6, his grade is plus three On the basis of this grading system the males of each category receive the following numerical rating:[2]

		Grams	
I	*A*	++ (7.5)	
	B	++ (6.8)	
II	*C*	— 3 (5.8)	31
	D	— 2 (6.3)	
	F	+ 2 (5.5)	
	G	+ 3 (6.1)	
	H	+13 (6.3)	
	L	+18 (4.7)	

III	*I*	— 7 (5.1)	—11
	J	+ 4 (4.5)	
	K	— 3 (4.7)	
	M	+ 3 (5.0)	
	O	— 8 (5.5)	
IV	*E*	—43 (5.0)	—36
	N	—12 (3.9)	
	P	+ 1 (4.7)	
	Q	18 (5.6)	
	R	— (4.4)	
	S	— (4.8)	

The dominance status of the males in the four categories shown in Figure 8 in relation to weights is thus correlated numerically by utilizing the grading system.

When the positive or negative numerical status of each animal and each category is considered, the true significance of the four categories or parts of Figure 8 is revealed. It is noted that the animals of categories I and II (combined) have a numerical value of +31, and an average weight of 6.12 grams, category III has a numerical value of —11 and an average weight of 4.96 grams, while category IV has a numerical value of —36 and an average weight of 4.73 grams. Figure 9 gives graphically the relationship between the

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[2] It might be argued that this grading system does not give proper credit to such animals as *A*, *B*, *R*, and *S*, the males at the top and at the bottom of the scale of dominance. However, if a percentage basis is used instead, the males are found to be arranged in essentially the same order, although *A*, *B*, *R*, and *S* receive a numerical rating:

		Percentage
I	*A*	100
	B	95
II	*C*	87
	D	87
	F	72
	G	68
	H	78
	L	58

		Percentage
III	*I*	48
	J	54
	K	42
	M	38
	O	17
IV	*E*	32
	N	18
	P	21
	Q	33
	R	10
	S	5
	T	0

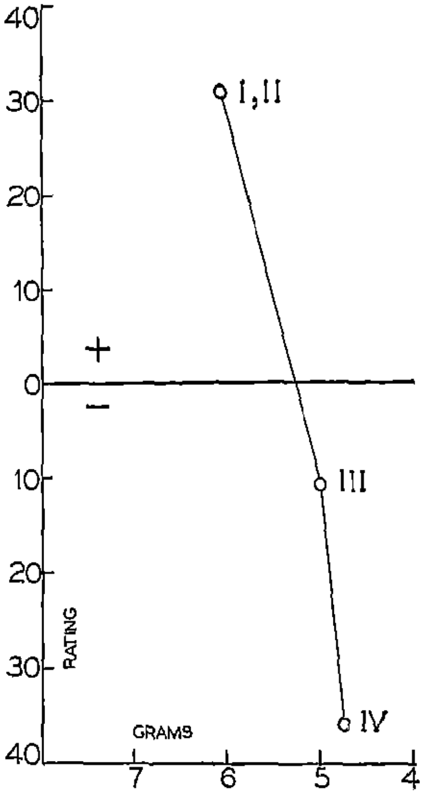

FIGURE 9
The average numerical rating of each category of males (I, II have +31, III has —11, IV has —36) plotted against the average weight of each category (I, II have 6.12 grams, III has 4.96 grams, IV has 4.73 grams)

numerical status of the four categories and the average weight of the males of each category This method of grading seems reasonable since each male is graded solely on his own ability to maintain or to improve the rank which he secured in the first cage Under this system no premium is attached to position of high rank nor is penalty attached to position of low rank provided this same rank is maintained in each of the six cages. It is interesting to note that categories

I and II stand almost as high above the line (+31) as category IV stands below the line (—36).

However, if weight and numerical status were true correlates of each other, that is, if the graph, Figure 9, were a straight line (assuming that category III retains its numerical status of —11), then

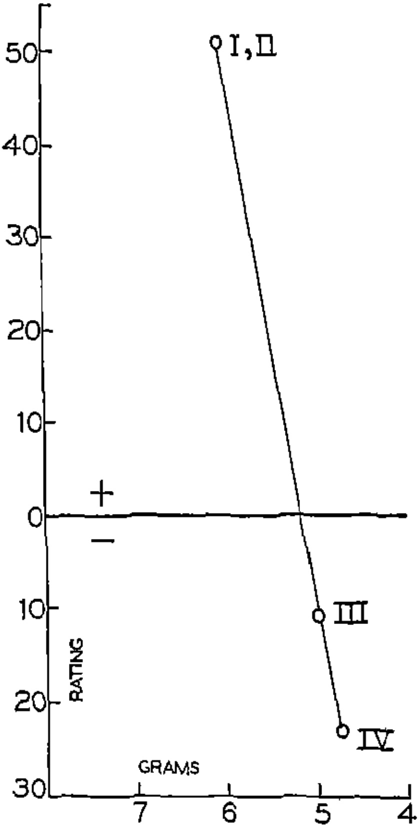

FIGURE 10

Based on the Theoretical Assumption that Average Numerical Rating and Average Weight of the Males in Each of the Four Categories are Directly Correlated

To show direct correlation between rating and weight it is necessary to ascribe a rating of +51 to I and II, a rating of —11 to III, and a rating of —23 to IV.

it would be necessary to raise the numerical rating of categories I and II to some point above +36 Also, the rating of category IV should be raised somewhat. The points where rating and weight meet, for categories I and II and IV, are found to be +51 and —23, respectively Categories I and II (combined) should be +51 while category IV should be —23. Figure 10 shows graphically these theoretical assumptions In other words, if weight were the sole factor to be considered, the males of categories I and II exerted themselves in combat only to the extent of 60 per cent of their actual fighting capacity. Likewise, the males of category IV performed only to the extent of 63 8 per cent of their capacity

DESCRIPTION OF REPRESENTATIVE COMBATS

It is useless to give details of each of the 98 combats witnessed during the period of the experiments. But several of the encounters should be described since they have considerable bearing on the general problem of diurnal lizard behavior.

Frequently the establishment of the dominance of a particular male over a group occurred during my absence from the laboratory. Among males of the same category in the same cage, especially in categories III and IV, the dominating male, after the initial defeat of other males, only exhibited his dominance for a few seconds during a period of three or four hours If I missed this brief exhibition of leadership, it was relatively simple to discover the dominant male by introducing a male from another cage. Usually in less than one minute after the newcomer was placed in the cage, if the sun was shining, the dominant male invariably revealed himself by extending his dewlap and challenging the newcomer.

Male *N* was often thus used to promote fighting. He weighed only 3 9 grams at the start of the experiment and 2.25 grams on May 11 when he died He was very agile but apparently had met with an accident some time before since his spinal column was bent out of alignment in both vertical and horizontal planes. Autopsy revealed only one testis present although both vasa deferentia were present Probably because of his physical handicap, for no other male behaved so queerly, he would deliberately advance toward a larger male, flash his dewlap, then run and hide when pursued by the challenged male. Within a few minutes *N* would show himself again, flash his dewlap, and the performance would be repeated. Five actual instances better illustrate his behavior. (1) May 31, 1935; 1.30 P.M. *N* was placed in Cage 2. Immediately he extended his dewlap while advancing toward five males, *G* and *E* among them, and apparently challenged them since they all turned quickly in his direction and extended their dewlaps as though they accepted the challenge *N* retreated and hid beneath a branch. The five males thus aroused proceeded to circle and challenge each other. Male *G* soon chased away all but *E* who held his ground until *G* locked jaws with him After being bitten twice *E* withdrew from the field leaving *G* dominating the cage This particular episode was witnessed by Mr. L A Hansborough. (2) *N* was placed in Cage 5, April 16, 1.00 P.M. He extended his dewlap and *L* immediately chased not only *N* but *O* and *I* as well All three left the field with *L* dominating the cage. (3) April 3, 3:00 P M., *N* bit *M* on the neck but was shaken off and chased away. (4) April 4, 12:30 P.M., *N* was seen climbing the screen of the cage toward *M*. When he attained a position higher than *M*, he thrust out his dewlap and compressed his body laterally. *M* responded in a similar way and quickly chased *N* down the screen (5) On April 11, 8·30 A.M., *N* was placed in cage 3 to incite fighting He immediately challenged all males present. *L* took up the challenge, chased *N*, and dominated the cage. *L* was then removed from the cage At 8·55 the same morning male *I* chased *N* and others, thus dominating the cage Male *I* was quickly removed and at 9·00 A M. *J* took up *N*'s challenge, chased the others, and became dominant *J* was removed and at 9:40 *M* took up *N*'s challenge and became dominant in turn in that cage.

A, as the records show, was not beaten by any other male during the course of the six series of combats. During his first few weeks in the laboratory a year previously, February 1934, he permanently injured his mouth while trying to escape But in spite of this handicap he held his rank as the only unconquered male in the hierarchy of 19 males. Very few males had the courage actually to fight with him. One such combat was particularly interesting. Male *H* became dominant in cage 4 at 8·40 A.M , April 11, and dominated Cage 5 at 8:55, fifteen minutes later. Accordingly he was placed in Cage 6 at 9.00 A M. *H* immediately extended his dewlap and strutted sidewise with body compressed laterally toward *A* who dominated Cage 6. *A*'s bright green color may have guided *H* toward him, since the dominant male is commonly green while all the rest are brown. It was quite apparent that *A* was surprised by this boldness and it was several seconds before *A* took the fighting pose and advanced toward *H*. *B*, in the brief interval, came from behind a branch and took up the challenge by advancing toward *H* with dewlap flashing. *H* continued to advance toward *A*, ignoring *B* who soon retired from the scene. *B*'s behavior in this episode was the only case observed that resembled in any way the pecker-peckee type of dominance described for the fowl by Schjelderup-Ebbe (7, 8) and by Murchison (4, 5) Both *A* and *H* persisted through the first or bluffing stage of the typical fighting pattern and entered the second or biting stage *A* opened his mouth very wide and literally thrust his lower jaw into H's mouth. *H* pulled back his head, thrust forward and caught *A* by the angle of upper and lower jaw A moment later he swung *A* over backward holding him suspended in mid-air After struggling, *A* broke the hold and dropped to the floor of the cage. He came toward *H* and was again caught and held in the same way During this struggle *A*'s color had changed to brown After breaking loose both males kept apart for ten minutes, but each eyed the other constantly Then *A* challenged *H* again. This time *H* retreated slowly and *A* again established himself as the dominant male of the cage. This encounter, lasting thirty minutes, was the longest and most interesting of all those witnessed during the course of the investigation

On May 9, at 10.00 A M , *R* had been in Cage 4 for several days when a small male, *T*, weighing 4.5 grams and which had never fought, together with male *S* was placed in cage 4 with *R* Within three minutes *R* crawled sidewise toward both *S* and *T* with body compressed and dewlap flashing. Neither of the newcomers responded to the challenge *T* moved toward *R* and passed him to climb to a branch. *R* followed *T*, threatening all the way. *T* stopped, *R* came alongside and continued to flash his dewlap and to compress his body. Still no answering challenge came from *T* who moved away. *R* then advanced toward S in like manner and received a similar negative response from *S* *R* was obviously puzzled, but made no attempt to touch the other males although he continued to threaten them for half an hour

DISCUSSION

From the evidence given in Table 1 it is clear that out of 98 observed encounters, in which dominance was definitely established, 90 were won by the dominating resident male, which had been in the cage at least 24 hours previously, against a strange male newly placed in the cage in spite of the fact that the latter had dominated the cage from which he came. The eight encounters in which the reverse was the case are.

F, April 18, 10·58 A.M , 18 minutes after being admitted, dominated Cage 6.

H, April 11, 8:55 A M., 15 minutes after being admitted, dominated Cage 5.

K, April 18, 10 25 A.M., 5 minutes after being admitted, dominated Cage 4.

O, April 15, 11·05 A.M , 15 minutes after being admitted, dominated Cage 4

Q, April 20, 9·45 A M., 45 minutes after being admitted, dominated Cage 3.

Q, April 20, 10·00 A M., 15 minutes after being admitted, dominated Cage 4

Q, April 20, 10:45 A.M , 45 minutes after being admitted, dominated Cage 5

R, April 25, 10·40 A.M., 20 minutes after being admitted, dominated Cage 3.

Of these eight encounters won by non-resident males only the first four are really significant, since in these cases the defeated resident males were known to fight readily. The three successive cases of dominance on the part of *Q* and the one for *R* are easily explained by the low dominance status of the males which they encountered.

The evidence strongly supports the contention of Noble and Bradley (6) that the male *Anolis* fight to retain a chosen territory against rival males. It further emphasizes the fact that little actual social life exists among adult Anolis of the same sex, particularly among males. In fact, although this purports to be a study of a social hierarchy in *Anolis*, it actually emphasizes the anti-social behavior of adult males. It is this feature of the behavior of the male *Anolis* which prevents anything approaching a straight-line dominance or a "pecking order" from occurring In fact the "pecking order" so common in fowls presupposes that members of the same species are bound together by a very positive social reflex as Murchison (4, 5) has clearly shown to be the case in the chick.

The cases cited also emphasize an additional fact in connection with behavior of male *Anolis* He has become so specialized structurally (referring particularly to the dewlap, dorsal crest, and ability to flatten the body laterally) that fighting can only take place after the males involved have extended their dewlap in a challenging manner If one male ignores the dewlap display of the other, no fighting takes place in the majority of cases. This was specially brought out in the case of *R* on May 9, 10 00 A.M., as mentioned above However, a male that stands fairly high in the scale of dominance will almost invariably respond to a dewlap of a challenging male by a similar display of his own.

The behavior of caged male *Anolis* is probably a modification of the behavior in the field Under natural conditions when a strange male approaches a particular territory which is in possession of another, a fight results, the outcome of which will depend upon two factors· first, the weights of the combatants, second, the psychological or emotional elements of the urge to hold territory. The beaten male retreats, leaving the victor in possession of the territory

In the cage the defeated males cannot leave the territory so the victorious male is kept continually in an aggressive mood because he constantly sees others in his domain Their proximity serves as an ever-present stimulus to fight to hold territory. Each day, therefore, the dominant male may be expected to express his territorial urge by the customary challenge of flashing dewlap, sidewise advance, and lateral flattening of the body

Since the dominant male was ordinarily removed and placed in the next cage as soon as he had defeated others, either by mere display or by actual fighting, and since dominance and weight are correlated (Figure 8), it follows that the weight of the average resident male which dominates a particular cage will be slightly greater than the weight of the average newly introduced male. Figures 2 to 7, however, show that there were many individual exceptions to this as evidenced by the zig-zag appearance of these graphs These exceptions (where a lighter male becomes dominant before another heavier male in the same cage) reveal very markedly the part played by the territorial urge

As a matter of fact, in all six cages, out of the total of 98 combats, 38 were won by males weighing less than other males in the same cage. When these particular combats took place, had the 38 cases occurred in the same numerical position in each cage, it is very doubtful if the weight-dominance correlation could have been shown to exist. But because they were scattered haphazard throughout the six cages they had little effect on the correlation. Figure 8 proves that weight and dominance are correlated to a considerable degree This is contrary to the findings of Murchison (4, 5) who records little or no correlation between mass and dominance in his careful and extensive studies of chick hierarchies.

In conclusion it might be suggested that the fighting pattern of males of *Anolis carolinensis* to defend or secure territory is made up of a chain of reflexes which are expressed in a more or less orderly sequence. Those which can be objectively studied and their order of sequence are.

1. Dewlap reflex
2. Dorsal crest reflex
3. Sidewise approach to rival male
4. Reflex causing a flattening of the body laterally
5. The biting reflex
6. Retreat reflex of the defeated male
7. Pursuit reflex of the victor
8. Dewlap reflex of the victor

Both males engaged in a combat will exhibit the first four reflexes listed here and the fifth, also, if both persist beyond the bluffing stage in the encounter. But usually the resident male will be the challenger and therefore the first to express each of the first four reflexes The sequence of the biting reflex will depend on the skill and strength of the rivals. The first five reflexes will appear in both but will vary in degree in each male. The sixth will appear only in the defeated male while the seventh and eighth will be expressed only by the victor.

If the dewlap reflex of the challenger yields no like response from the second male, the only reflex in the chain which will be expressed by the latter will be sixth or retreat reflex, unless he simply ignores the challenger The retreat reflex is more apt to be the response on the part of the second male if the challenger has already conquered him and then challenges him again later. However, if the second male be newly introduced into the cage, he rarely ignores the challenge.

The first four reflexes produce what might be called an intimidating mechanism which has apparently evolved to cause the males to appear as large and imposing as possible to each other. As a bluffing device it is certainly successful since many encounters end at this point in the fighting pattern.

SUMMARY

Experiment reveals for the first time in any reptile form a social hierarchy which differs in many respects from that of fowls Nineteen males of *Anolis carolinensis* ranging in weight from 7 5 grams to 3.9 grams arrange themselves in a series of dominance ranking which is closely correlated with weight. The largest males stand at the higher end of the scale and smallest stand at the lower end of the scale of dominance

The urge to acquire and to hold a certain restricted territory is very marked. The resident male (that has been in a particular cage for 24 hours or more) wins in 91 per cent of the combats not only because he is heavier than the non-resident (42 per cent of such combats being won by lighter males) but also because he fights harder to defend territory than the non-resident does to acquire it

The males are grouped in three distinct categories. (1) Those ranking very high in dominance with a numerical rating of +31 and an average weight of 6 12 grams (2) Those ranking intermediate in dominance with a numerical rating of —11 and an average weight of 4 96 grams (3) Those ranking very low in dominance with a numerical rating of —36 and an average weight of 4 73 grams.

The fighting pattern consists of eight reflexes which are overtly expressed in the following order· (1) dewlap reflex, (2) dorsal crest reflex, (3) sidewise approach to rival male, (4) reflex causing a flattening of the body laterally, (5) the biting reflex, (6) retreat reflex of the defeated male, (7) pursuit reflex of the victor, (8) dewlap of the victor

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UNE ÉTUDE D'UNE HIÉRARCHIE SOCIALE CHEZ LE LÉZARD *ANOLIS CAROLINENSIS*

(Résumé)

L'expérience montre pour la première fois chez un reptile une hiérarchie sociale Dix-neuf mâles d'*Anolis carolinensis*, variant de 7, 5 grammes à 3, 9 grammes, se sont rangés dans une serie d'évaluation de dominance étroitement corrélée avec le poids Les plus grands mâles se sont trouvés à l'extrémité supérieure et les plus petits à l'extrémité inférieure de l'échelle de dominance

Le mâle résidant a gagné neuf dans un total de 98 combats Ceci à eu lieu en partie parce qu'il a été plus lourd que le non-résidant et en partie parce qu'il a lutté plus fort pour défendre le terrain qu'a lutté le non-résidant pour l'acquérir.

On a groupé les mâles en trois catégories: (1) Ceux d'une dominance supérieure avec une évaluation numérique de plus 31 et un poids moyen de 6, 12 grammes (2) Ceux d'une dominance moyenne avec une évaluation numérique de moins 11 et un poids moyen de 4, 96 grammes (3) Ceux

d'une dominance inférieure avec une évaluation numérique de moins 36 et un poids moyen de 4, 73 grammes

La forme de lutte s'est composée de huit réflexes exprimés d'une façon manifeste en l'ordre suivant: (1) Reflexe du fanon, (2) Réflexe de la crête dorsale, (3) Approche du côté au mâle rival, (4) Aplanissement du corps latéralement, (5) Réflexe de mordre, (6) Retraite du mâle vaincu, (7) Poursuite du vainqueur, (8) Réflexe du fanon du vainqueur.

L Evans

EINE UNTERSUCHUNG EINER SOZIALEN HIERARCHIE BEI DER EIDECHSE *ANOLIS CAROLINENSIS*

(Referat)

Diese Untersuchung offenbart zum ersten Mal bei irgendeinem Reptil eine soziale Hierarchie Neunzehn Mannchen der Gattung *Anolis Carolinensis*, die von 7, 5 g bis 3, 9 g wogen, ordneteten sich in einer Reihe der Herrschung, die eng mit dem Gewicht korrelierte Die grossten Mannchen standen am hoheren Ende und die kleinsten standen am niedrigeren Ende einer Skala der Herrschung

Das wohnhafte Mannchen gewann 90 von 98 Kampfen Dies war teilweise die Folge davon, dass es schwerer als das nichtwohnhafte Reptil war und teilweise weil es schwerer kämpfte, um sein Gebiet zu verteidigen als das nichtwohnhafte Reptil, um es zu erwerben.

Die Mannchen wurden in drei Kategorien eingeteilt (1) hoch an Herrschung mit einem Zahlrang von Plus 31 und mit einem durchschnittlichen Gewicht von 6, 12 g (2) Dazwischenliegend an Herrschung mit einem Zahlrang von Minus 11 und mit einem durchschnittlichen Gewicht von 4, 96 g (3) Niedrig an Herrschung mit einem Zahlrang von Minus 36 und mit einem durchschnittlichen Gewicht von 4, 73 g

Das Kampfmuster bestand aus acht Reflexen, die ausserlich in folgender Ordnung ausgedruckt wurden. (1) Dewlap Reflex, (2) Ruckenkammreflex, (3) seitliche Annahrung an den Nebenbuhler, (4) das Niederdrucken des Korpers zur Seite, (5) der Beissreflex, (6) Zuruckziehen des unterworfenen Mannchens, (7) Verfolgung des Siegers, (8) Dewlap Reflex des Siegers

L Evans

STIMULUS- VERSUS RESPONSE-DIFFERENTIATION IN DELAYED REACTIONS OF CHIMPANZEES*

From the Yale Laboratories of Primate Biology

H. W Nissen, C. R Carpenter[1], and J. T. Cowles

In his 1913 monograph (5) Hunter lists "three different methods of delay which might have appeared and in point of fact did appear in our delayed reaction experiments" These three methods, in abbreviated form, are as follows (1) Maintenance of orientation of all or part of the body during the delay, (2) Absence of such maintained orientation; (3) Staying in the part of the restraining compartment nearest one of the reaction boxes The investigation showed that rats and dogs were dependent on the first method for successful response whereas raccoons apparently could use any one of the three methods.

Hunter's study raised a question of fundamental importance for theory of behavior mechanisms which subsequently has received scant consideration. What is the mechanism which enables an organism, not maintaining its gross orientation or position in the restraint compartment, to respond correctly after an interval of time? What is remembered? Is the sensory-perceptual impression received during the baiting or presentation period somehow revived at the end of the delay interval? Or, instead, is it the initial, partial movement or tendency which is "held in leash" until it can find its outlet in complete, overt response? Hunter, postulating a representative or ideational process as being necessary in delayed reaction, states the problem as follows·

> . the representative process must stand for either the sensory or motor aspect presented in the genetically lower level of behavior. there are from the standpoint of function two classes of ideas —ideas of objects or those representing the stimulus aspect of the situation, and ideas of movement or those representing some aspect of the movement or its sensory consequences. (pp 73-74)

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The process which occurs in successful delayed response must be based, finally, on an earlier event or occurrence. the giving of the "cue" before the delayed interval.

> "Ideas" are the residual effects of sensory stimuli which are retained and which may be subsequently excited The revival, moreover, is *selective and adaptive to the solution of a definite problem, and when aroused, they function successfully* as a necessary substitute for a definite component of the objective stimulus aspect of the problem. (5, p 73)

When an animal sees food in a certain part of the environment and immediately goes to it, there is presumably both a differentiation of the stimulus situation (differentiating a certain part of the visual field from the rest) and a differential movement (going in one direction rather than in another) If, now, a delay period intervenes before the animal can make its overt response, and food is no longer immediately present to the senses, at least one of these differentiations must be present or be revived if the response is to be "correct" That is, either one part of the stimulus situation must function differently than the rest of the situation, *or* the situation as a whole *must stimulate one certain movement rather than other movements. In the first case the essential element which "bridges" the gap and is effective at the end of the delay interval is stimulus-differentiation, in the second case it is response-differentiation* [2]

The stimulus situation after the delay period, therefore, may function either as an undifferentiated whole or selectively, one part evoking a different response than other parts Likewise the response may be a non-differential movement of approach (or avoidance) or it may be a critically differentiating response, such as grasping with the left hand rather than with the right These are at least logical alternatives; whether they are psychologically possible remains to be discovered.

Several points of importance in the above analysis should be emphasized · (1) We are here considering the total situation as it exists

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[2] We recognize that stimulus- and response-differentiation at the end of the delay interval *may* be regarded as merely different aspects of what is fundamentally the same process or mechanism Whether we are dealing here with two distinguishable processes or, instead, with two *aspects of a unitary* mechanism, is open to question The hypothesis that there are two distinct (although doubtless related) mechanisms would appear more fruitful for analytical purposes and is adopted *throughout our discussion*

after the subject has gotten his cue, not before. As already indicated above, at some time or other there must be both stimulus- and response-differentiation; our problem is which of these functions when overt response occurs.[3] (2) In stimulus-differentiation the non-differential approaching response aroused by a certain stimulus must be "translated" into the specific movements required by the situation. In response-differentiation this "translation" takes place before the delay interval, after the delay an approaching tendency must supplement the critical, differentiating response. The same essential elements, therefore, enter into both types of delayed reaction under discussion. The temporal relations of these elements, and the connection or association by which the delay interval is bridged, however, may be different. The terms, stimulus- and response-differentiation, are descriptive not of the complete mechanism involved in a delayed reaction but only of that portion effective after the delay interval has set in. (3) The differentiated stimulus may be in the external sensory field (e.g., visual characteristics of the container which was baited with food) or it may consist of kinaesthetic impulses resulting from a turning of the body or of the eyes, for instance, in a certain direction.[4] Or a combination of such direct and indirect stimuli may act as the differentiating cue. (4) The differential response or tendency may be directly and specifically the critical movement which the situation requires, or it may be a more general movement in the direction of one of the food containers.

We may briefly recapitulate. Before the delay the subject sees food being placed into one of the boxes.[5] The possible sources of stimulation at this time are especially: (1) the total, undifferentiated stimulus situation, (2) visual and other external stimuli from the food and from the food container, (3) kinaesthetic stimuli from the eye or postural muscles as the subject looks at or turns toward the baited container, (4) kinaesthetic stimuli from an approaching response or tendency. On the response side we must consider especially (1) eye movements and postural orientation toward the food containers, (2) an approaching or forward-going response (Any of the responses mentioned may, of course, be implicit or incipient as well as explicit or overt). All these processes may be more or less simultaneous, so that association or conditioning between any of the aforementioned stimuli and responses must be considered possible. Depending, then, on what is associated with or conditioned to what, the mechanism operative at the end of the delay interval will be *stimulus-differentiation or response-differentiation.* The following diagrams are simplified representations of the two possibilities:

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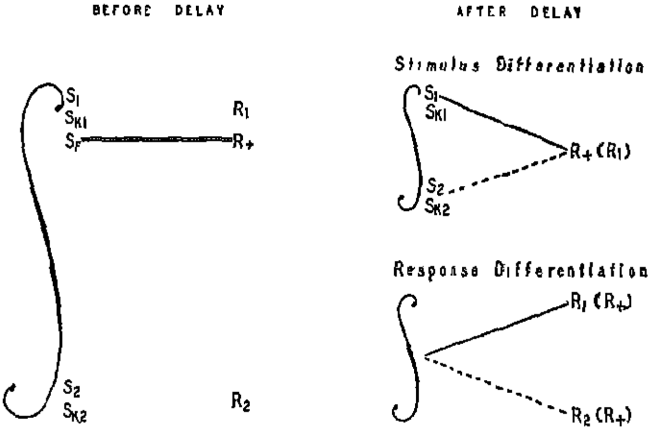
[3] We are not considering the possibility of both mechanisms operating at the same time in the same individual. One or the other would be sufficient, and the principle of parsimony would be against assuming both to be operative simultaneously. On the other hand, it is conceivable that either type of adjustment might operate (exclusively or predominately) in the same organism, depending largely on certain features of the situation, such as the relative obtrusiveness of several factors in it. Thus large and brightly colored boxes might favor stimulus-differentiation, whereas a novel and complicated device used by the subject in attaining the lure might favor response-differentiation. The problem then becomes one of determining the relations between the two mechanisms and the factors favoring operation of one and the other.

[4] It will be noted that our analysis here differs importantly from that of Hunter, who lumps "ideas of movement" with their "sensory consequences", see quotation, page 74.

[5] For the sake of simplicity we are using as illustration the direct method of delayed reaction with two food containers. Use of the indirect method or of multiple containers would necessitate no important modifications.



The large S represents the undifferentiated stimulus situation, S_1 and S_2 visual stimuli from the baited and unbaited containers respectively, S_{k1} and S_{k2} kinaesthetic stimuli from orientation towards the containers, S_f stimuli from the food. Solid double line represents the principal reinforcing agent, a single solid line the association established before and effective after the delay interval, a dotted line the main alternative association Symbols in parentheses represent elements added to the critical differentiation to complete the response.

Although we have worded our discussion almost exclusively in the terminology of stimulus-response psychology, it should be noted that the distinction made between two mechanisms remains essentially the same even if revival of a sensory impression without any intervening responses or response tendencies, or the revival of a movement or movement tendency without reference to intervening stimuli, is assumed.

The experiment here reported was designed as a first step in an attack on the problem stated above In brief, we provided a situation permitting variation of the distance between two food containers and also of the distance between the ends of two cords by which the subject drew in the containers (See Figure 1, p.). The influence of these two variables was measured in terms of accuracy of performance obtained under the several conditions

It was expected that if differentiation or fractionating of the stimulus situation is the critical factor, the spatial separation of the two food boxes should influence scores markedly, while the degree of differentiation of the two alternative overt responses would be of small consequence; if, on the other hand, differentiation of the critical response is the determining factor, the spatial separation of the boxes would be of decidedly less import than the distinctness of the two response points.

As was suggested above, however, differentiation of the stimulus situation may occur in respect to the points of response (rather than in reference to the food containers themselves), and therefore the effects of degree of separation of these points perhaps cannot be distinguished from those of response-differentiation This is quite true, but is significant only in the eventuality that the degree of spatial separation of these points influences performance which, as it happens, it did not do in this experiment It is also possible that the greater distance between the food containers might favor response-differentiation as well as stimulus-differentiation. To this we can only say that it seems more reasonable to attribute the effectiveness of spatial separation of the containers to the latter kind of differentiation, especially when the separation between response points is shown to be of little or no consequence.

Influence of spatial separation of the food containers in delayed response situations has been suggested or demonstrated by several writers (3, 5, 7, 8, 9, 10). In all these studies, however, the variable distances employed have applied equally and simultaneously, as far as can be known, to both the visual (or perceptual) field and to the spatial distinctiveness of the critical responses In the present investigation the attempt has been made to separate these factors experimentally for the purpose of determining which of the two aspects of separation is the significant one

APPARATUS, PROCEDURE, SUBJECTS, AND PRELIMINARY TRAINING

The apparatus employed is shown in Figure 1. The restraining cage, it will be noted, is large enough to give ample opportunity for locomotion in all three dimensions Construction of the cage is such that the animals can climb the side walls and cling to the wire-mesh ceiling. There is little opportunity for visual distraction. A ceiling light directly over the restraining cage and a 75-watt bulb directly over the working platform give bright, constant illumination The experimenter is out of sight but can observe the subject while the doors are raised for baiting and for response The animal can see only the hand and lower arm of the experimenter as he reaches through one of the square openings in the fiber-board panel in order to bait one or the other of the two food containers. The cloth screen surrounding the working platform on three sides prevents the subject from seeing anything beyond the working platform. The wire mesh panels on the sides of the platform prevent the animal from pulling the cloth screen when the side doors are raised. The platform is painted light brown, all other woodwork is natural pine. The fiber-board panel is light tan, the cloth screen consists of light cream-colored muslin The boxes are painted black (In Experiments 1 and 3, aluminum cups, mounted on a black wooden base, 115 cm. in diameter, 1 9 cm high, were used as food containers. The cups, having a maximum diameter of 10 5 cm., are sufficiently deep (6.0 cm) so that the animal cannot see whether or not they contain food.) The cords are white, 4 mm in diameter. The several arrangements[6] shown in inset, Figure 1, require different lengths of cords; to one end of each cord is fastened a snapper

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[6] Throughout this report the capitals, *S* and *M*, will be used to refer to the side and middle positions, respectively, of the food containers, while a small *s* or *m* will designate corresponding positions of the ends of the cords nearest the cage

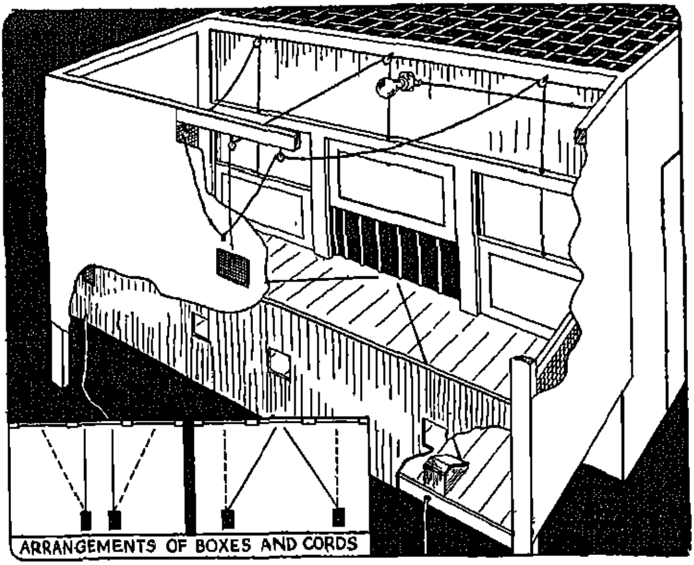


FIGURE 1

PERSPECTIVE DRAWING OF APPARATUS, SHOWING ALSO PART OF RESTRAINING CAGE AND (INSERT) THE FOUR ARRANGEMENTS OF FOOD CONTAINERS AND CORDS EMPLOYED

Portions of the cloth and composition-board screens have been cut away in order to show essential parts of the apparatus. Boxes and cords are in the *S-m* position (see text). The middle door is raised, showing bars through which the animal worked. Dimensions (all in centimeters): Restraining cage: 180 by 180 and 184 high. Each of the three windows is 54 wide, 25 high. Distance between windows, 4.5. The platform, 184 wide on cage side, 198 wide on experimenter's side, and 91 deep, is 38 above floor level. Boxes are 10 wide, 10.5 long, 10 high. Distance between boxes, center to center, 137 when in *S*-position, 26 when in *M*-position. Distance between ends of cords nearest restraining cage: 137 when in *s*-position, 26 when in *m*-position. Fiber board screen is 198 long, 46 high, the four openings cut into this screen are 10.5 square, bottom edges 20 above the platform level, distances between these openings same as for the food boxes. Muslin screen completely surrounds platform and extends from below the platform level to 184 above floor level. One-way vision screen, 15 wide, 10 high, is centered over long dimension of the platform, 52 above platform level. Heavy wire-mesh screens, along the ends of the platform, are 92 high. The light is centered 125.5 above platform level.

which the experimenter can readily hook to an eye on the front of the box or base of the cup. At the other end of each cord is an iron ring which clips over a nail at the appropriate place in the platform.

The cord lengths are so adjusted that in each position the cord is just long enough, i.e., is fairly straight. Projecting through the fiberboard panel, directly behind each of the four positions of the food containers, is a cord with a snapper hooking to the back side of the box with which the experimenter can prevent the animal from making a second choice in case the first response is wrong.

The general procedure employed was as follows: after the animal had been placed in the restraining cage, the experimenter adjusted the food containers and cords for the first trial. With the experimenter out of sight, the appropriate door or doors facing the working platform were raised. The experimenter reached through the panel opening over the correct container and, as soon as the animal was looking at the lure, placed it into the container. In preliminary training the animals had learned not to pull the cords at this time. As the hand was withdrawn, the door or doors were closed, and at the same time a stop watch was started. At the end of the specified delay limit, the designated doors were raised and the animal was allowed to pull in one of the containers. During the early tests, especially, the animals sometimes pulled first one, then the other cord. When the closed boxes were being used, a "response" was counted as such only when one of them had actually been opened. The animal was not permitted to open the second box. When the open cups were employed as food containers, a response was recorded for the first cup to cross the half-way mark between iron grille and back of platform, since beyond this point it might have been possible for the animal to see into the cup. Only one choice was allowed. After a response had been made and the lure taken, the doors were closed and the containers and cords were adjusted for the following trial. The time between trials was fairly constant at about 45 seconds. By means of a stop watch, the time elapsing between the raising of the doors at the end of the delay interval and the first pull on either cord was recorded for each trial.

The four chimpanzee subjects are described briefly as follows:

Name	Numerical designation	Sex	Approximate age	Weight
Alpha	28	F	4 yrs	20.75 kilos
Bimba	26	F	5 yrs	18.05 kilos
Frank	25	M	4½ yrs	16.20 kilos
Velt	31	M	5 yrs.	18.10 kilos

All the subjects had been used previously in other experiments. Velt was the only one of the four with prior experience in delayed reaction; he had been used in an experiment on the effects of amount of reward on delayed reaction performance in which the pull-in technique was employed. Alpha and Bimba were accustomed to drawing in food boxes in a visual discrimination experiment. None of the animals had had any previous acquaintance with the apparatus used in this study.

Training preliminary to the tests recorded in the following pages consisted in getting the animals emotionally adapted to the experimental situation, and in training them to pull in the food boxes after a short delay interval and not during the demonstration or baiting period. The various container- and cord-arrangements which were to be employed later were each used an equal number of times during the preliminary training, so that no one of them would be favored over the others From two to seven sessions of about twenty minutes each were given the several subjects for this preliminary adaptation.

EXPERIMENT 1

Subjects in this experiment were Alpha and Bimba, each used once a day. During both baiting (presentation) and response periods all three doors of the restraining cage were opened simultaneously. The four situations or arrangements of cords and food-containers shown in Figure 1 (insert) were presented in an irregular order, each situation an equal number of times during each experimental session. The system of left-right and situation sequences used was designed to meet the following requirements: (1) an equal number of right and left positions within each successive group of four trials, (2) the baited container to be on the same side no more than three successive times, (3) each of the four situations to appear once in each group of four successive trials, (4) the same situation never to appear on two successive trials, (5) each situation to be followed an equal number of times by each of the other three situations, and (6) each situation to begin an equal number of experimental sessions The latter condition was not met completely since it was found impossible to adhere in all cases to the plan of having 16 trials during each experimental session In order to carry out this system we made up four sequences of 16 trials each for the left-right position and also four sequences of 16 trials each for the four situations:

Left-right sequences:

A) R L L R R L R L L L R R L R L R
B) L R R L L R L R R R L L R L R L
C) L R L R L L R R R L R L L R R L
D) R L R L R R L L L R L R R L L R

Situation sequences (situations 1, 2, 3, and 4)

I) 1 2 3 4 2 4 1 3 4 3 2 1 3 1 4 2
II) 2 3 1 4 1 2 4 3 2 1 3 4 2 3 1 4
III) 3 2 1 4 3 4 1 2 3 1 2 4 3 2 4 1
IV) 4 2 1 3 1 2 4 3 4 1 3 2 1 4 2 3

It is to be noted that left-right sequence *B* is a mirror-image of sequence *A*, and that sequences *C* and *D* are the reverse orders of *B* and *A*, respectively Situations 1, 2, 3, and 4 correspond, respectively, to box- and cord-positions *M-m*, *M-s*, *S-m*, *and S-s*.

In order to make up our situation and left-right combinations, the following formula was used; it provides for 16 sessions of 16 trials each, or a total of 64 trials for each of the four situations Both subjects were given a total of 32 sessions of 16 trials each; the formula here given was therefore repeated for the second 16 sessions Combination of left-right and situation sequences for 16 days.

I A, II B, III C, IV D, IV A, III B, II C, I D,
I, B, II A, III D, IV C, IV B, III A, II D, I C

For both animals, throughout this experiment, the reward or incentive was one-sixteenth orange, including the skin, per trial; each piece weighed approximately 10 grams The maximum number of trials per experimental period was 16, so that by making no errors the animal could get a total of one orange per session For Bimba there were always 16 trials per session, for Alpha, who became restless and excited with prolonged work, the number was cut down to eight or 12, as shown in detail below.

The delay interval was increased from time to time at a rate which would produce sufficient errors to demonstrate any differences in difficulty among the four situations and which, at the same time, would not unduly discourage the subjects.

Results. Tables 1 and 2 show the number of errors made by Alpha and Bimba, respectively, on each of the four situations during each of 32 successive series of 16 trials each. Since each situation appeared four times within one series, the maximum number of

TABLE 1

ALPHA

Number of errors on each of four situations in successive series of 16 trials each, with increasing delay intervals Number of trials per situation per series 4.*

Series number	Trials per experimental period	Delay in seconds	Situation			
			M-m	*M-s*	*S-m*	*S-s*
1	16	3				*1*
2	16	4	1	1		
3	16	5	2			
4	16	6				
5	16	7	1	2		
6	16	10	1	1		
7	16	10	1			
8	16	12	1	1		
9	16	12		1		
10	16	15				
11	16	15				
12	16	20				
13	16	25				
14	16	30				
15	16	30	1			
16	16	30	1	2		
Total errors, series 1-16			9	8	0	1
Total trials, series 1-16			64	64	64	64
Score (% correct)			85.9	87.5	100	98.4
17	8	30				
18	12	30		1		
19	12	30	1			
20	12	30		2		
21	12	30		1		
22	12	30	*1*			
23	16	30	*1*			
24	12	30				
25	12	30	1			
26	12	40	1			
27	12	40	*1*			
28	12	40		*1*		
29	12	40				
30	12	45				
31	12	45	*2*	*1*		
32	12	50	*2*			
Total errors, series 17-32			10	6	0	0
Total trials, series 17-32			64	64	64	64
Score (% correct)			84.5	91	100	100
Total errors, series 1-32			19	14	0	1
Total trials, series 1-32			128	128	128	128
Score (% correct)			85.2	89.1	100	99.2

*Wrong choices of container to animal's left are italicized, errors to the right are unitalicized.

TABLE 2

BIMBA

Number of errors on each of four situations in successive series of 16 trials each, with increasing delay intervals Number of trials per situation per series. 4*

Series number	Trials per experimental period	Delay in seconds	Situation *M-m*	*M-s*	*S-m*	*S-s*
1	16	1-3		1-*1*		
2	16	3	1	1		
3	16	4-5	2			
4	16	7-10		1	*1*	
5	16	12	1	1	*1*	
6	16	15-20				
7	16	22-26		1		
8	16	30-40				
9	16	45		1		
10	16	60	*1*	2		
11	16	60	1	2		
12	16	60				
13	16	60	*1*			
14	16	60	*1*			
15	16	60	1	1		
16	16	60	*1*			
Total errors, series 1-16			10	12	2	0
Total trials, series 1-16			64	64	64	64
Score (% correct)			84 4	81.3	96 9	100
17	16	75				
18	16	75	1			
19	16	75	*1*			
20	16	90		1		
21	16	90		1		
22	16	90		2		
23	16	90	*1*	1		
24	16	90	1			
25	16	90				
26	16	90	*1*	1		
27	16	90				
28	16	90				
29	16	105	*2*			
30	16	105	*1*			
31	16	105		1		
32	16	120	*1*			
Total errors, series 17-32			9	7	0	0
Total trials, series 17-32			64	64	64	64
Score (% correct)			85.9	89 1	100	100
Total errors, series 1-32			19	19	2	0
Total trials, series 1-32			128	128	128	128
Score (% correct)			85 2	85.2	98.4	100

*Wrong choices of container to animal's left are italicized, errors to the right are unitalicized.

errors possible on one situation, per series, is four, two errors represent a chance score

The lowest score obtained on any series was 81-per-cent correct choices, that is, three errors in 16 trials The maximum score on a series was 100-per-cent correct. It is possible that we could have obtained differentiation between the situations more rapidly if the delay intervals had been increased more frequently and by larger steps, but this would have involved the risk of an emotional upset which probably would have resulted in chance scores on all situations. As it was, our subjects worked at a fairly high level of accuracy throughout the 512 trials given each, and the errors are distributed rather evenly throughout this period

Using Yule's formula (11, p. 257, formula 2) the standard error of a proportion,

$$\sigma_p = \sqrt{\frac{pq}{n}}$$

and Edgerton's table of standard errors (1), we have computed the reliability of the differences in percentage accuracy scores between each of the six pairs of situations (128 trials each) for each subject The difference in scores between situations *M-m* and *M-s*, and between *S-m* and *S-s*, are statistically unreliable for both Alpha and Bimba; the highest among these four reliability coefficients is 1.5. The differences between *M-m* and *S-m*, *M-m* and *S-s*, *M-s* and *S-m*, and between *M-s* and *S-s* are reliable in both cases, the lowest critical ratio (Difference/Sigma of the difference) for Alpha is 3 47, obtained by comparing situation *M-s* with *S-s*, and the smallest ratio for Bimba is 3.9, found in relating situations *M-m* or *M-s* with *S-m*

We may say, therefore, that as far as accuracy scores of either subject are concerned, *the distance between the two alternative points at or to which the overt motor response must be made is relatively immaterial*, regardless of the distance between the two food containers. *The distance between the food containers, on the other hand, is important,* regardless of the distance between the ends of the two cords which are used to draw in the food containers

The response time, that is, the time elapsing from the moment that the doors were raised at the end of the delay interval, permitting the animal to respond, until the moment that the subject began to pull

TABLE 3

MEAN, MEDIAN AND MODE OF RESPONSE TIMES FOR TRIALS WITH AND WITHOUT ERRORS

	Alpha All situations Correct (*N*-478)	Errors (N-34)	Total (*N*-512)	Bimba All situations Correct (N-468)	Errors (*N*-38)	Total (N-506)*
Mn	4.28	9.82	4.65	4.67	6.37	4.80
Mode	2.0	2.0		2.0	2.0	
Md	2.0	4.0		3.0	3.0	

**Records for 6 responses lacking*

on one of the cords, was measured on each trial by means of a stop watch. We thought that this index might further differentiate the several situations employed, show changes as testing proceeded, and possibly indicate something about the relative degree of "certainty" with which the subjects made their responses. Actually the differences obtained are small and not always consistent in direction. The data are summarized in Tables 3 and 4. The following points may be noted: (1) The distributions of response times are decidedly skewed, most of the values fall close to the minimum, one to two seconds. (2) *Times are longer in the trials containing errors than in errorless trials.* (3) *Alpha shows a slight increase in speed of response from the first to the last half of the trials, Bimba manifests* some slowing up as testing continued. (4) Response times tend to be longer when the containers are close together (situations *M-m* and

TABLE 4

AVERAGE RESPONSE TIMES FOR EACH OF THE FOUR SITUATIONS AND FOR CERTAIN COMBINATIONS OF THESE

	Situation *M-m*	*M-s*	*S-m*	*S-s*	*M-m* & *M-s*	*S-m* & *S-s*	*M-m* & *S-m*	*M-s* & *S-s*
				Alpha				
Series 1-16	4.5	5.9	3.8	5.2	5.20	4.50	4.15	5.55
Series 17-32	3.8	4.9	3.0	3.4	4.35	3.20	3.40	4.15
Series 1-32	4.15	5.40	3.40	4.30	4.78	3.85	3.78	4.85
				Bimba				
Series 1-16	3.8	5.2	3.4	5.0	4.50	4.20	3.60	5.10
Series 17-32	5.7	5.4	5.8	4.4	5.55	5.10	5.75	4.90
Series 1-32	4.79	5.27	4.60	4.71	5.03	4.65	4.69	4.99

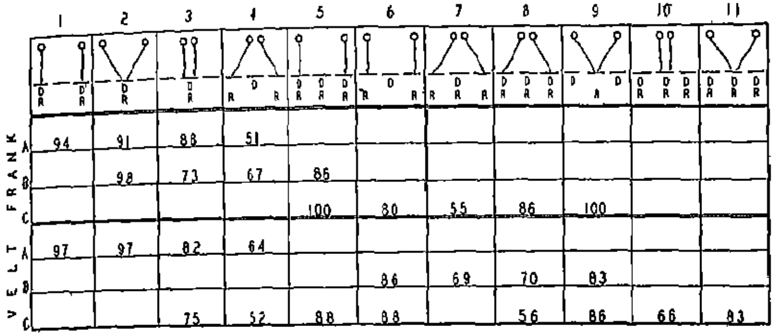
M-s) than when they are further apart (*S-m* and *S-s*). (5) Response times tend to be longer when the points of overt response are far apart (*M-s* and *S-s*) than when they are close (*M-m and S-m*).

Certain qualitative differences in the behavior of Alpha and Bimba should be mentioned. Alpha habitually remained seated close to the center part of the response-grille, moving to either side for response only after the doors were opened following the delay Bimba, in striking contrast to Alpha, nearly always moved about the restraining cage during the delay and between trials. This movement was experimentally facilitated by introducing, after the first quarter of the experimental periods (series 9-32), a systematic distraction. This consisted in dropping one-half of the incentive into one of the far corners of the cage at a fixed time after initiation of the delay period. The other half of the reward was obtained at response, if this was correct. It is interesting to note that in spite of the large differences, both "natural" and experimentally induced, in the amount of gross movement occurring during the delay interval, the relative accuracy of response on the four situations is very similar for the two subjects.

EXPERIMENT 2

Experiment 2 was carried out with two male subjects, Frank and Velt. The same apparatus was employed and, in general, conditions were similar to those obtaining in Experiment 1. The principal differentiating feature of the present trials was the manner in which the three opaque doors, separating the subject from the working platform, were operated. In all trials given Alpha and Bimba, all three doors were raised together, both during baiting of the boxes and at the end of the delay interval In the present experiment, one, two, or three doors were raised, and not always the same ones at the end of the delay as at the beginning. It was hoped, in this way, to analyze in greater detail the factors promoting relatively greater and lesser accuracy of performance.

One experimental session, consisting in from 16 to 32 consecutive trials, was given per day. All situations (arrangements of food boxes, cords, and doors raised before and after the delay) which were to be compared were given an equal number of times within each day's work Instead of an irregular sequence, however, as employed in Experiment 1, all the day's trials on a given situation followed



		1	2	3	4	5	6	7	8	9	10	11
FRANK	A	94	91	88	51							
	B		98	73	67	86						
	C					100	80	55	86	100		
VELT	A	97	97	82	64							
	B						86	69	70	83		
	C			75	52	88	88		56	86	66	83

FIGURE 2
SITUATIONS AND SCORES, EXPERIMENT 2

each other in immediate succession. Thus, if situations Number 1, 2, 3, and 4 were being studied, and there were 16 trials per day, the sequence of trials would be 1, 1, 1, 1, 2, 2, 2, 2, 3, 3, 3, 3, 4, 4, 4, 4; during the following days the order in which the four situations appeared would be varied Left-right position sequences were the same as those used in Experiment 1, orders *A, B, C,* and *D* were used in sequence, regardless of the number of trials per experimental session. Situation sequences were made up for four, five, and eight situations which would provide an equal number of trials on each within a work period, which would give each situation each possible position in the temporal order an equal number of times, and in which, as far as possible, each situation was followed by every other situation an equal number of times Since the latter condition could not always be met within the number of trials given, it was attempted to compensate for this factor by giving the two subjects different parts of the completely balanced order

Results. Figure 2 shows diagrammatically the situations employed and the accuracy scores (percentages of responses correct) obtained by each subject. The food boxes are represented by small circles, the cords by the parallel, converging or diverging lines, the doors opened during demonstration or baiting by the letter *D,* the doors opened when the animals responded by the letter *R.* All scores for a group indicate situations which were given together, i.e., which appeared during each of several consecutive work sessions.

TABLE 5

Conditions Obtaining in Experiment 2 and Number of Errors for Each Situation (Numbered as in Figure 2) in Successive Test Series, Subjects Frank and Velt

Group	Series	Delay	Reward	No trials per session	No. sessions	Total trials	No trials per situation	Situation number										
								1	2	3	4	5	6	7	8	9	10	11
							Frank											
A	I	10	1/12 Or.*	16	8	128	32	4	5	2	14							
	II	15	1/12 Or.	16	8	128	32	0	1	6	17							
B	III	25	1/24 Or.	32	4	128	32		1	9	10	7						
	IV	40	1/24 Or.	32	4	128	32		0	8	11	2						
C	V	40	1 Pnt**	40	4	160	32					0	7	14	7	0		
	VI	50	1 Pnt	40	4	160	32					0	6	15	2	0		
							Velt											
A	I	15	1/12 Or.	16	8	128	32	1	0	6	13							
	II	25	1/12 Or	16	8	128	32	1	0	4	9							
	III	40	1/12 Or.	16	8	128	32	1	3	7	13							
B	IV	40	1/24 Or	24	8	192	48						7	14	13	10		
	V	50	1 Pnt	32	4	128	32						4	11	11	4		
C	VI	50	1 Pnt	32	8	256	32			5	16	3	5		14	3	11	5
	VII	50	1 Pnt	32	8	256	32			11	15	5	3		14	6	11	6

*Or —Orange
**Pnt—Peanut

In Table 5 are shown further details of procedure, and the number of errors made during successive series of 32 (in one case 48) trials on each situation. The numbering of the several situations is the same as in Figure 3 Chronological sequence is obtained by reading from top to bottom of the table. Response times are shown in Table 6

Considering first Group A, both animals, we find that the situations in which the food boxes are far apart (1 and 2) consistently give higher scores than those (3 and 4) in which they are close together There are only small score differences between situations 1 and 2; in the former the alternative points of response are widely separated, in the latter they are in close proximity. There is, however, a very marked difference between scores on situations 3 and 4, and the direction of difference is in favor of the situation in which there is the *smaller* distance between the alternative response points. It may be noted that in situation 4 the animal does not get the same view of the boxes as it had when it saw them being baited; the subject is forced to go to one of the choice (response) points before it can see the boxes.

The group *B* tests on Frank again demonstrate the effectiveness of spatial separation of the boxes The score difference between situations 2 and 5 probably reflects disturbance occasioned by the novelty of all three doors being raised simultaneously. Situation 4 again has the lowest score, although the difference between it and situation 3 is not as pronounced as before.

The findings up to this point are in general supported by Frank's group *C* tests. The score on situation 6, however, is lower than that on 8, which is contrary to what might be expected from the greater proximity of the boxes in the latter case. Perhaps the most obvious explanation for the lower score on 6 is the same as that given above for situation 4: the subject does not get the same view of the boxes at the end of the delay interval as at the beginning, and it must move to one of the response positions before seeing the boxes On situation 5, where the conditions would seem to be exactly the same as on 6 except for the features just mentioned, the accuracy score is 20 per cent higher. The much lower score on situation 7 than on 8 suggests that the important element is the discrepancy between the number of doors raised before and after the delay interval The

TABLE 6

AVERAGE RESPONSE TIMES IN SECONDS FOR EACH SITUATION IN SUCCESSIVE TEST SERIES AND GROUPS

Subjects *Frank* and Velt

Series		Situation number 1	2	3	4	5	6	7	8	9	10	11
					Frank							
I		2.22	2.02	2.06	3.28							
II		1.26	1.41	1.73	2.76							
	Average, Group A	1.74	1.71	1.89	3.02							
III			1.30	2.12	2.48	1.44						
IV			1.61	3.39	2.89	1.44						
	Average, Group B		1.45	2.75	2.68	1.44						
V						1.23	1.61	2.48	1.81	1.42		
VI						1.28	2.50	2.75	1.97	2.17		
	Average, Group C					1.25	2.05	2.61	1.89	1.79		
					Velt							
I		2.06	1.80	2.53	4.31							
II		2.16	2.23	3.38	5.47							
III		2.83	2.56	3.25	5.53							
	Average, Group A	2.35	2.19	3.05	5.10							
IV							3.77	4.90	4.32	3.53		
V							4.05	5.47	5.11	2.41		
	Average, Group B						3.91	5.18	4.71	2.97		
VI				3.94	7.14	3.94	4.92		6.97	3.72	3.53	4.45
VII				3.27	5.89	4.36	5.44		5.34	3.89	3.08	3.92
	Average, Group C			3.60	6.51	4.15	5.18		6.15	3.80	3.30	4.18

high score on situation 9 would then have to be explained by assuming that being forced to go to the correct side gave the animal a superior and perhaps unique cue for response.[7]

The scores made by Velt in group *B* suggest that for this subject mere difference between the doors employed at presentation and at response is not the important factor which it is for Frank—compare scores on situations 7 and 8. It seems fair to conclude, at least, that for Velt spatial separation of the boxes is the more influential factor This conclusion is supported by a comparison of scores on the several situations in group *C*, which shows consistently better performance when the boxes are spatially well separated than when they are close together.

Any marked changes which occur as a result of practice should be indicated by a comparison of successive series within the same group, Table 5. Comparison of absolute scores from one series to the next is, of course, not legitimate, since variations in reward, length of delay interval, and number of trials per session are doubtless responsible, to an unknown extent, for fluctuations in the general level of performance It will be noted that the relative difficulty (as measured by error scores) of the several situations within a group did not vary greatly from one series to the next There are very few changes in relative position or ranking according to scores. In this connection may be pointed out also the rather close agreement, in respect to relative difficulty of the several situations, between the records of the two subjects

Inspection of Tables 5 and 6 indicates a relationship between number of errors and average length of response time. Ranking the situations within each group for both subjects (1) according to accuracy scores and (2) according to average response time, and applying the formula for rank differences, we obtain positive coefficients of .80, 60, and .97 for Frank, .95, 80, and .27 for Velt. It will be noted that Frank's response times are quite consistently shorter than those of Velt.

In regard to amount of gross movement in the restraining cage during delay intervals, Frank and Velt may be distinguished in the same way as were the two subjects of Experiment 1. Frank usually did not move from the spot occupied during presentation until after the doors had gone up for response, although he occasionally pounded with his hands on those doors during the delay, as if impatient for opportunity to respond. Velt, on the other hand, moved around almost continuously, stopping only very briefly to watch the baiting.[8]

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[7] Compare somewhat similar results and conclusions of Honzik (4) and of Elder and Nissen (2)

In summary it may be said that the results of Experiment 2, in addition to confirming those of Experiment 1, suggest two further factors influencing accuracy of delayed response performance: (1) Forced movement of the subject towards the correct side of the cage before the delay interval favors accuracy (2) Accuracy is decreased if the subject must go to one of the choice points after the delay and before it can see both food containers. The later point gives further indication that response-differentiation was not the essential cue in these tests.

EXPERIMENT 3

In a previous study from this laboratory (6) it was shown that in delayed reaction chimpanzees make higher scores with small incentives when large-incentive trials are interspersed among the small-incentive trials than when an experimental session consists solely of the latter. This finding is interpreted as indicating a perseverative effect of the reward; the use of a large incentive influences not only the degree of accuracy in that trial but also in the subsequent trial or trials.

Experiment 3 was designed to determine whether successive trials influence each other also when not the incentive, but the difficulty of the problem, varies from trial to trial It has been shown above that situations *S-s* and *S-m* are easier, or elicit higher accuracy scores, than situations *M-s* and *M-m* when reward and delay intervals are the same for both. The question arises as to whether accuracy on the former two situations was depressed by the presence of *M-s* and *M-m* trials and whether, conversely, accuracy on the latter two situations was raised by intervening *S-s* and *S-m* trials. The problem was attacked by presenting each pair of situations alone and together in a balanced series.

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[8] Neither maintained-orientation towards the "correct" food container or towards the end of the corresponding cord, nor remaining on the "correct" side of the cage, was observed in any of our subjects. Why chimpanzees do not avail themselves of these apparently obvious and simple methods of meeting the problem situation is itself an interesting question

Alpha and Bimba were used as subjects in this experiment, which followed immediately completion of Experiment 1. Except for the combination of situations within a work session, conditions remained unchanged. The delay interval was kept constant for each animal throughout this part of the work For Alpha a delay of 45 seconds, for Bimba of 120 seconds, was used. Reward was the same for both animals and of the same quality and quantity as before: one-sixteenth orange per trial There were always 16 trials per session, one session per day. The sequences in which situations followed each other within a series and the right-left sequences were irregular and, for the two animals, balanced The frequency of shifts from one situation to another was the same when two or four situations were included within a series

The situation-combinations and results are shown in Table 7. It may be seen that in each instance the accuracy scores on the two difficult situations, *M-m* and *M-s*, are higher when these are interspersed by trials on the easy situations, *S-m* and *S-s*, than when they alone make up a series Although the direction of these differences is consistent, their magnitude is not great enough to yield statistical reliability. The scores on situations *S-m* and *S-s* are practically maximum, whether they are mixed with *M-m* and *M-s* trials or whether they comprise all trials of a series

It may be said, therefore, that the presence of "easy" situations within a series tends to raise accuracy on the more difficult situations as contrasted to accuracy when the latter stand alone Degree of difficulty, it seems, has a perseverative effect similar to that previously demonstrated (6) for amount of reward

There is no indication in our data that the presence of difficult situations affects accuracy on easy situations unfavorably. The latter result may be a function of the general level of performance at which the animals worked in these tests.

SUMMARY

1. A delayed reaction apparatus, employing the pull-in technique, was arranged to permit independent variation of the distance (1) between two food containers and (2) between the ends of the two cords by which the subject could draw in the containers

2. Data obtained with four young chimpanzees show conclusively

TABLE 7

NUMBER OF ERRORS IN EACH SITUATION FOR EACH SESSION OF 16 TRIALS WHEN THE COMBINATION OF SITUATIONS EMPLOYED VARIED, SUBJECTS ALPHA AND BIMBA.

Maximum errors possible per session with two situations, 8 with four situations, 4

Total trials per situation per animal, 32, of which 16 are in combination with one other situation, 16 in combination with three other situations

Series number (16 trials each)	Situations used				Number of trials, each situation	Errors			
						Mm	Ms	Sm	Ss
					A. Alpha				
1	Mm	Ms	Sm	Ss	4	0	0	0	0
2			Sm	Ss	8			0	1
3			Sm	Ss	8			0	0
4	Mm	Ms	Sm	Ss	4	0	0	0	0
5	Mm	Ms	Sm	Ss	4	1	1	0	0
6	Mm	Ms			8	2	0		
7	Mm	Ms			8	2	2		
8	Mm	Ms	Sm	Ss	4	2	0	0	0
Total errors, Series 1, 4, 5, 8 (16 trials each situation)						3	1	0	0
Totals errors, Series 2, 3, 6, 7 (16 trials each situation)						4	2	0	1
Percentage correct, Series 1, 4, 5, 8						81	94	100	100
Percentage correct, Series 2, 3, 6, 7						75	88	100	94
					B Bimba				
1	Mm	Ms	Sm	Ss	4	1	0	0	0
2	Mm	Ms			8	3	0		
3	Mm	Ms			8	3	3		
4	Mm	Ms	Sm	Ss	4	1	1	0	0
5	Mm	Ms	Sm	Ss	4	0	1	0	0
6			Sm	Ss	8			1	0
7			Sm	Ss	8			0	0
8	Mm	Ms	Sm	Ss	4	1	0	0	0
Total errors, Series 1, 4, 5, 8 (16 trials each situation)						3	2	0	0
Total errors, Series 2, 3, 6, 7 (16 trials each situation)						6	3	1	0
Percentage correct, Series 1, 4, 5, 8						81	88	100	100
Percentage correct, Series 2, 3, 6, 7						63	81	94	100

that, for the distances used, increased separation of the food receptacles favors accuracy of response, whereas the distance between the ends of the two cords has little influence on performance scores.

3. Results from Experiment 2 suggest two further factors affect-

ing performance: (*a*) Forcing the animal to go to the correct side of the restraining cage before initiation of the delay provides a superior and perhaps unique cue, of which chimpanzees do not, as far as our observations show, spontaneously avail themselves. (*b*) The necessity of going to one or the other choice point before both containers are in view, at the end of the delay interval, decreases accuracy of performance.

4. Response times (time elapsing between the end of the delay interval and the first pull on one of the cords) are on the average longer for trials with error than for those in which response is correct.

5 Two subjects, Alpha and Frank, characteristically sat very quietly during the delay intervals, while the other two, Bimba and Velt, moved around in the cage irregularly and almost constantly during these periods. This striking difference in behavior had no marked or consistent effect on relative scores obtained on each of the several situations.

6. Experiment 3 indicates that accuracy scores on "difficult" situations are raised by interspersing these with trials on "easy" situations

The results summarized in paragraphs 2, 3, and 5 are interpreted as indicating that the cue which spanned the interval in these delayed reactions did not involve, as its essential element, either the particular critical response required at the end of the delay or the sensory differentiation of the two response-points It is suggested that the critical association was one between the visual appearance of the baited food container and an approaching response or tendency. The data, however, do not rule out the fourth main possibility, namely, of an association between the undifferentiated stimulus situation and a critical (differentiating) response toward the food containers

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THE BEHAVIOR OF CATS ON SEVERAL PROBLEMS IN ASSOCIATION*

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Although the ability of the cat to form the association between the manipulation of a mechanical device and the securing of reward has been confirmed by a number of investigators—Hobhouse (4), Thorndike (8), Berry (2), Shepherd (5), Teyrofsky (6, 7), Adams (1)—little is known of its ability to form the association when the cause and the effect are widely separated both temporally and spatially In view of this fact, the purpose of the present investigation was to arrange an experimental situation in which the medium of the cat's response was more extensive and less integrated than in the usual problem-box situation

Since an entire room was selected for the medium of response, the problem device and the reward could be separated by considerable space, thus increasing the difficulty of solution. Four specific problems were formulated, based upon the characteristics of the experiment room and the complexity of the problem device. These were.

1. Is the cat able to make the association between the pressing of a small platform at one side of the experiment room with the obtaining of a reward of food?
2. Is it able to distinguish the different directions of the experiment room if the problem device is shifted to the several sides of the room?
3. Is it able to recognize this problem device (the platform) when it is included as a part of a larger configuration?
4. Is it able to shift its manipulative act from pressing the platform to lifting up a ring, when the latter is substituted for the platform?

Three cats were used in the investigation They belonged to the colony formerly maintained by Dr. Adams at Yale. All were born

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and reared in a laboratory and had not been used in any previous experiments. They were Trash, a brown tabby, female, aged 1½ years; Ila, a silver grey female, aged 1 year; and John, a yellow male, aged 1 year. During the present investigation they were housed in a large airy room on the third floor of a university building with freedom for walking and climbing The same diet as that used by Dr. Adams with his colony at Yale proved satisfactory The reader is referred to Dr Adams' paper for the formula (1). To obtain sufficient motivation the animals were kept hungry for 20 to 24 hours, and were then fed after the final trial of the day. They were also fed at this same hour on other days. A large part of the experimentation was conducted in the evening. After the first few days the cats appeared well adjusted to the laboratory routine, and were usually well motivated.

The procedure followed was to place the cat alone in the experiment room with the experimenter making observations through a small peep-hole in one of the walls. The experiment room was built of insulating material (Homosote board), with each side 408 cm long and 198 cm. high. The door was placed at the center of the north wall, which was also in the direction of the living quarters. The only break in the homogeneity of the room as seen from the inside was the door-knob. The floor was painted a battleship grey, but the walls were left unpainted Lights of 110 volts were placed near each of the four corners of the ceiling to insure ample lighting

To determine if the cat could make the association between pressing the platform and securing the reward, problem *A* was presented, in which the platform was placed at the center of the east wall of the room (Figure 1). To find whether the cat could then distinguish between the different directions in the room, problems *B* and *C* were presented in which the platform was moved to the center of the south and west walls, respectively The platform was made of Homosote board and was painted with a black and white horizontal stripe, with the black turned toward the wall (Figure 2). Its dimensions were: length 19 5 cm., width 14 cm., thickness 1 cm. It stood 6 cm from the floor resting on an electrical contact key. A base with two electrical poles supported the key and platform. To the poles wires were attached leading to an electric magnet.

A piece of liver was used as reward throughout the experiment.

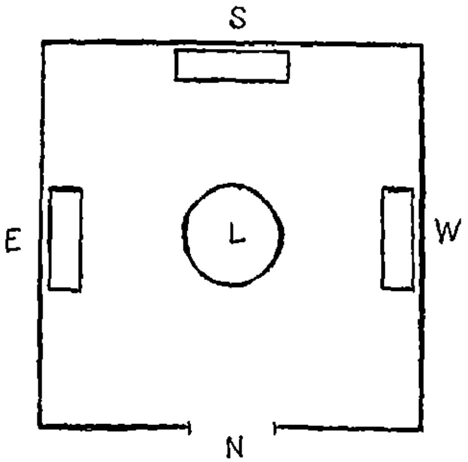

FIGURE 1

EXPERIMENT ROOM

Plan of the experiment room, showing the platform in place for each of the problems, *A*, *B*, and *C*. *L* denotes the cover over the liver at the center of the room. Distance between liver and platform at any side of room is 189 7 cm

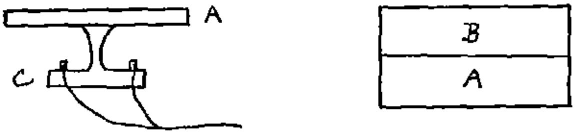

FIGURE 2

PLATFORM

I. Side view of platform (*A*) platform itself, (*C*) base of platform with wire leads. II Top of platform (*A*) part painted white, (*B*) part painted black

This was placed beneath a heavy wire circular cover 28.5 cm in diameter, which allowed the cat to see and smell the liver without being able to obtain it until the problem was solved.

Problems *A*, *B*, and *C* were solved when the cat pressed the platform This brought together the contact points under the platform, which formed the circuit through the electric magnet. A piece of steel at the end of a rod in this way became magnetized A niche was made in the rod and into this niche a wooden bar was held in suspension when the circuit was open, but was released when the circuit was closed. The bar, when it was released, served to lift the cover from the liver by means of a cord and pulley, thereby enabling the cat to secure the reward The cord was fastened to the cover by a hook and snap At the other end of the cord were tied several weights so that the cover could be raised more rapidly. The batteries and magnet were located on an outside wall of the experiment room A pile of cushions and pillows muffled the noise of the weights when they fell, so that distractions from this source were reduced to a minimum

In order to study the ability of the cat to recognize the platform when it was contained as part of a larger configuration, it was attached to the end of a box 56 cm by 38 cm., painted gray (Figure 3). The upper end of the platform came flush with the upper end of the box. To press the platform in this case, therefore, the cat was obliged to reach up about four inches. The box with platform attached was first placed at the center of the west wall in problem *D,* at the center of the south wall in problem *E,* and at the center of the east wall in problem *F.*

FIGURE 3
BOX WITH PLATFORM INVERTED AND ATTACHED TO THE END

In problem *G* the box was retained as part of the configuration, but a ring was substituted in place of the platform. This ring, as shown in Figure 4, was on the top of the box so that solution of the problem demanded lifting up the ring. By means of a mercury cup placed inside the box, the cover was raised from the liver in the same way as described above in the case of pressing upon the platform. During problem *G* the box was located at the center of the south wall

Four or five trials were usually given in a series on each day of

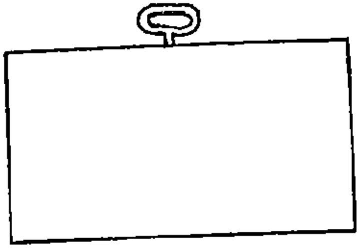

FIGURE 4

Box with Ring Attached at the Top

experimentation, with about five minutes between trials. It was sometimes found necessary, however, to vary this schedule in order to conform to the motivation of the animal. Generally there was an interval of two days between each series of trials. The norm of mastery was the immediate manipulation of the problem device in four trials out of five. This precluded any random or explorative behavior of the animal after it was put into the experiment room.

The results are represented in Tables 1 to 4. These show the length of time in seconds per trial for each cat and the method of

TABLE 1

Length of Time in Seconds Per Trial for Each Cat and the Method of Solution Used in Each Trial on Problem *A*

	John			Trash			Ila	
Trial	Time in sec.	Solution	Order of response	Time in sec	Solution	Order of response	Time in sec.	Solution
1	1892	2 f paws	L - W → E	252	4 paws	L → E	720	Failure
2	1200	Failure	L - W → E	86	4 paws	L-W → E	720	Failure
3	464	Nose	L N → E	111	r.f paw	W-L → E	720	Failure
4	969	Nose	L → E	600	l f.paw	L → E	600	Failure
5	1021	Nose	L → E	255	r f paw	L → E	600	Failure
6	854	Nose	L → E	121	r f paw*	L → E	600	Failure
7	215	Nose	L → E	102	r f paw*	L → E	600	Failure
8	151	Nose	L → E	28	r f paw	L → E		
9	5	Nose	L → E	8	r f paw	L → E		
10	22	Nose	L → E	11	r f paw	→ E		
11	8	Nose	→ E	19	r f paw	→ E		
12	5	Nose	→ E	10	r f paw	→ E		
13	4	Nose	→ E	6	r.f paw	→ E		
14	4	Nose	→ E	6	r f paw	→ E		
15				6	r f paw	→ E		
16				11	r f paw	→ E		

TABLE 2

LENGTH OF TIME IN SECONDS PER TRIAL FOR EACH CAT AND THE METHOD OF SOLUTION USED IN EACH TRIAL ON PROBLEM *B*

		John			Trash	
Trial	Time *in sec.*	Solution	Order of *response*	Time *in sec*	Solution	Order of *response*
1	20	Nose	E → S	14	r f paw	L → S
2	12	Nose	e → S	13	r f paw	L → S
3	55	Nose	E → S	12	r.f paw	L → S
4	41	Nose	E → S	90	No solution	L → E
5	26	Nose	E → S	15	r f paw	L → S
6	21	Nose	E → S	14	r.f. paw	→ S
7	7	Nose	→ S	9	r.f paw	→ S
8	9	Nose	→ S	8	r.f paw*	→ S
9	5	Nose	→ S	101	r.f paw	E → L → E → S
10	5	Nose	→ S	10	r f. paw	e → S
11				99	r.f. paw	L → S
12				12	r.f paw	→ S
13				9	r f paw	→ S
14				16	r f. paw	→ S
15				7	r f. paw	→ S

TABLE 3

LENGTH OF TIME IN SECONDS PER TRIAL FOR EACH CAT AND THE METHOD OF SOLUTION USED IN EACH TRIAL ON PROBLEM *C*

		John			Trash	
Trial	Time	Solution	Order of response	Time	Solution	Order of response
1	11	r f paw	S-E → W	10	r f paw	L-S → W
2	9	Nose	S → W	14	r f paw	L-S → W
3	8	Nose	S-E → W	13	r.f paw	L-S → W
4	8	Nose	S-E → W	9	r f. paw	L-S → W
5	4	Nose	S-E → W	8	r.f. paw	L-S → W
6	6	Nose	S-E → W	4	r.f paw	→ W
7	3	Nose	S-E → W	3	r f. paw	→ W
8	5	Nose	S-E → W	9	r f. paw	S → W
9	44	Nose	S-E → W	7	r.f. paw	L-S → W
10	5	Nose	S-E → W	6	r f paw	L-S → W
11	11	Nose	S-E → W	4	r f. paw	→ W
12	7	Nose	S-E → W	16	r f paw	S-E → W
13	5	Nose	s-e → W	11	r.f paw	→ W
14	4	Nose	s-e → W	5	r.f. paw	S → W
15	15	Nose	e → W	4	r f paw	→ W
16	16	Nose	S-E → W	9	r.f paw	→ W
17	3	Nose	s-e → W	5	r.f paw	→ W

TABLE 4

LENGTH OF TIME IN SECONDS PER TRIAL FOR JOHN DURING PROBLEMS *D*, *E*, AND *F*

	Problem *D*		Problem *E*		Problem *F*	
Trial	Time in sec.	Order of response	Time	Order of response	Time in sec	Order of response
1	720	E-S → W	7	→ E	4	l → S
2	720	E-S → W	17	L-W → E	4	→ S
3	124	N-S-L → W	6	L → E	5	→ S
4	258	E-S → W	7	→ E	4	→ S
5	44	E-S → W	14	W → E	4	→ S
6	11	E-S → W	15	e → W	14	l → S
7	22	E-S → W	9	→ E	6	→ S
8	35	E-S → W	17	→ E	22	l → S
9	48	E-S → W	28	→ E	11	→ S
10	36	E-S → W	46	l → E	5	→ S
11	17	L → W	16	l → E	10	→ S
12	8	E-S → W	6	→ E		
13	14	E-S → W	4	→ E		
14	13	E-S → W	5	→ E		
15	17	E-S-→ W	4	l → E		
16	11	E-S → W	3	→ E		
17	19	E-S → W				
18	15	e-S → W				
19	5	E-S → W				
20	5	e-S → W				
21	8	e-S → W				
22	5	E-S → W				
23	7	E-S → W				
24	5	e-s → W				
25	6	e-s → W				
26	6	e-s → W				
27	6	e-s → W				

response used in each trial. In reading the columns in the tables under the caption "order of responses" the letters *E*, *N*, *S*, and *W* refer to the different sides of the room in the order in which the animal went to them. The *L* refers to sniffing of the liver and trying to obtain it by biting and clawing. The small letters indicate that the cat only looked at that particular side of the room or at the liver without actually going to it.

It will be seen by examining Table 1 that one cat, IIa, failed completely on problem *A*. For this reason she was not used on any of the following problems. The other two cats, however, will be seen to have mastered the problem in a comparatively few number of trials, John showing the better record of the two. The time in seconds is a fair measure of the amount of random activity on the part of the animal. In the first few trials it could be said that the cats were motivated by the desire to explore, and, in the case of both these animals, stepping onto the platform was apparently accidental at its first occurrence, since the cat continued its explorative behavior and did not see that the liver was now obtainable. Soon after the animals were placed in the room for the first trial, they found the liver, and proceeded to attack it vigorously with tooth and claw In subsequent trials, until the association between platform and liver was learned, the cats went to the liver as soon as they were put into the room.

The reactions of Ila in the experiment room were quite different. She appeared to be frightened by the solitary confinement, and spent a great deal of time in sitting near the door, washing herself vigorously. She sniffed of the platform several times, but did not step on it in any of the trials.

It will be noticed in Table 1 that there is a sudden drop in the length of time required in trial 9 for John, and in trial 8 for Trash. This marks the point where the two cats no longer spent much time in attacking the cover over the liver, but went to the platform soon after entrance into the experiment room. In the successful trials they disregarded the liver until they had pressed the platform They then turned to look at the cover as it was raised, and immediately dashed to seize the reward.

The ways in which these two animals pressed the platform differed markedly, as the table shows. *After the first trial, it will be* seen that John rubbed his nose on the edge, which behavior was habitual throughout the remainder of the experiment The response of Trash was less stereotyped, however, as may be observed. Although she used her right fore paw in most cases, she sometimes used her left fore paw, this apparently depending upon the direction from which she came to the platform

The data of Table 2 show that both Trash and John learned to distinguish the south side of the room from the others, although John's record is superior to that of Trash In the first trial both cats went first to the east side of the room where the platform had been located in problem *A*. They appeared to be disturbed by failure to find it They then attacked the cover over the liver, a type of response that had dropped out at the end of problem *A* Thereupon both animals walked around the room, discovering the platform in its new location, and pressing it as in problem *A*. The habit of going to the east side of the room persisted in the case of John until trial 7, in which the length of time dropped from 21 seconds to 7 seconds After this he went directly to the platform at the south wall. After trial 1 Trash did not approach the east wall again until trial 9, when suddenly this response reappeared, together with a large amount of random activity. In the subsequent trials on the problem, however, she went directly to the north side of the room

The results of shifting the platform from the south wall to the west wall in problem *C* are shown in Table 3 It proved to be more difficult for the cats to distinguish this direction than that of problem *B*. Probably this can be accounted for by the fact that the west wall was directly opposite the east wall. As the data of the table show, John never went directly to the west side of the room upon entrance, but always came to it after having gone around the east and south sides, usually in that order. Trash however, after trial 7, went directly to the west wall, making the counter-clockwise turn Both cats tended to go to the south side considerably more often than to the east, indicating the greater strength of the more recent response in problem *B* over that of problem *A*.

In Table 4 are presented the results of problems *D*, *E*, and *F*. It will be noted that John was the only cat able to respond to the platform as a part of the larger configuration of the box. As is shown in the first column, problem *D*, in which the platform was first fastened to the box, was the most difficult, although the platform remained at the same side of the room as in problem *C* The rapidity with which the cat recognized the platform is remarkable, however, since in trial 3 the platform was found and rubbed with the nose as it had been when placed on the floor. This manner of manipulating the platform continued throughout these problems

Problems *E* and *F* were readily learned, as the time scores show, and the animal after the first few trials was going directly to the platform at the end of the box. The experience gained in problems *B* and *C* undoubtedly facilitated it.

John was carried over to problem *G*, in which the platform was removed from the end of the box, and the ring to be lifted placed on top After failure to lift the ring in ten successive trials of 20 minutes each the problem was considered to be insoluble In the first few trials the animal went directly to the box and searched for the platform, but only on the end of the box to which it had been fastened in the preceding problems. Not finding it, he rubbed his nose as much as ten times on the corner of the box, turning to look at the cover over the liver after each act. In later trials this behavior disappeared and the unadaptive responses which were common early in the experiment reappeared. These included attacks with teeth and claws upon the cover over the liver, long periods of sitting on the floor between the box and the cover, devoting most of the time to washing. Occasionally his behavior became redirected toward the box, but in the last two trials it disappeared completely

This experiment, the writer believes, presents a clear picture of the behavior of a cat when in a baffling problem situation Each of the cats used *apparently progressed to the level of response within* its capacity, and thereafter manifested unadaptive behavior when placed in more difficult situations Washing and mewing are comparable to the frequent plucking of the hairs described by investigators who have studied monkeys in difficult problem situations.

The results obtained show quite clearly that the cat can make the association between the manipulation of a mechanical device and the securing of reward, although they are widely separated in an experi*ment room. It is evident, therefore, that the cat is not limited in its* response to the spatial and temporal juxtaposition characteristic of the usual problem box. The results also indicate that cats can learn to distinguish directions, since they so readily found the platform when it was shifted from one side of the room to another. It is suggested that cats can respond to an element previously experienced—in this case the platform—when it is contained as a part of a new configuration—the platform on the box. The data on this *point, however*, are too meager to permit generalizations, since only one of the three cats could master the problem The platform, wherever found by John, served to call up the same response in the animal—rubbing it with the nose.

CONCLUSIONS

It may be concluded from the results of this experiment that:

1. The cat can learn the association between the manipulation

of a mechanical device and the reward of food, even when they are widely separated both temporally and spatially.

2. The cat can find and manipulate in the same way the mechanical device when it is changed in location from one direction of the room to another.

3. Changing the mechanical device from a distinct element to a configuration in which it is only a part does not tend to prevent the cat's recognition of it or alter the response. Only one of the three animals solved this problem, however.

4 The substitution of a ring to be lifted for the platform to be pressed is apparently too difficult for the cat, since all three animals failed.

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LE COMPORTEMENT DES CHATS SUR PLUSIEURS PROBLÈMES D'ASSOCIATION

(Résumé)

Cette expérience a été un test de l'habileté du chat à former l'association entre la manipulation d'un machin mécanique et l'obtention d'une récompense, *quand ces deux aspects ont été plus séparés temporellement et* spatialement que l'on n'a fait ordinairement dans la situation ordinaire de la boîte à problème. Le machin mécanique employé a été une petite plateforme, dont la pression par le chat a fermé de quelque façon un circuit

électrique pour enlever un couvercle lourd de la récompense de foie Cette récompense s'est trouvée au centre de la salle et la plate-forme d'un côté à la distance de 189,7 cm. Deux des chats employés comme sujets ont appris cette association dans un temps relativement court, 14 et 16 épreuves, respectivement. *Le troisième n'a pas du tout réussi, et on ne l'a donc employé* sur aucun des problèmes avancés. Quand on a changé la plate-forme aux plusieurs côtés de la salle, le chat a su faire l'association, avec peu d'intervention de la première association. Le problème a été plus compliqué quand l'on a attaché la petite plate-forme au bout d'une grande boîte, changeant ainsi la configuration L'un des chats a appris ceci sans difficulté, puisque la plate-forme a fait venir la même réponse qui a eu lieu quand la plate-forme a été isolée Tous les animaux n'ont pas réussi à apprendre à enlever un anneau sur le sommet de la boîte, quand on l'a substitué à la plate-forme sur le bout de la boîte

WINSLOW

DAS VERHALTEN DER KATZEN BEI MEHEREN ASSOZIATIONSPROBLEMEN

(Referat)

Dieses Experiment war eine Prüfung der Fähigkeit einer Katze, die Assoziation zwischen der Handhabung eines mechanischen Apparates und der Erreichung einer Belohnung zu bilden, wenn diese zwei Seiten des Versuches sowohl zeitlich als auch räumlich weiter getrennt werden, als bis jetzt bei der gewöhnlichen Problemkastensituation getan wurde Der mechanische Apparat bestand aus einer kleinen Plattform, die durch einen Druck von der Katze auf irgendeine Weise einen elektrischen Strom schloss, welcher einen Deckel aufhob, um die Leberbelohnung aufzudecken. Die Belohnung war in der Mitte des Zimmers und die Plattform stand zur Seite in einer Entfernung von 189,7 cm Zwei der gebrauchten Katzen lernten diese Assoziation verhältnismässig schnell in 14 bzw. 16 Proben Der dritten misslang es vollkommen und folglich wurde sie in fortgeschrittenen Experimenten nicht gebraucht Wenn die Plattform nach den verschiedenen Seiten des Zimmers verschoben wurde, war die Katze fähig, die Assoziation mit wenig Einmischung von der ersten Assoziation zu bilden. Das Problem wurde dadurch verwickelter gemacht, dass die Plattform an ein Ende des Kastens befestigt wurde, so dass die Konfiguration geändert wurde. Eine der Katzen bemeisterte dies ohne Schwierigkeit, indem die Plattform dieselbe Reaktion hervorrief, die vorkam, wenn die Plattform isoliert war. Es misslang allen Tieren, eine Glocke auf dem Kasten ertönen zu lassen, wenn sie durch die Plattform am Endes des Kastens ersetzt wurde.

WINSLOW

VOCAL SYMBOL FORMATION AS A FUNCTION OF READING ABILITY*

From the Department of Psychology, Brown University, and the Boston Psychopathic Hospital

M. S. CARD AND F. L WELLS

SUMMARY

The experiments[1] here reported utilized a short test composed of a series of ten subtests which might be regarded as five pairs of equivalent tests, one of which served as a control for the other· (*a*) a test in the naming of a series of actual objects and one in reading the printed names of the objects previously identified; (*b*) a similar pair for pictured objects and (*c*) another for colors, (*d*) tests in the naming upper and lower case letters, respectively, (*e*) one in naming digits and one in simple addition. In *a, b,* and *c* one series of tests permits a measurement of the capacity for symbol formation essential to naming while the other does the same with respect to reading, one capacity may be stated in terms of the other and the relation between the two is set forth. The test was administered to school pupils who were normal readers of different mental age levels; a series of norms was obtained and ratios were figured; estimates of the distinct capacities at various grade levels and numerical statement of relationships was thus provided. The manifestation of specific reading disability by a *relatively* low proficiency in the reading tests is presented in the brief note of clinical observations on the use of this test with cases of reading disability

SUBJECTS

In choosing the subjects for these experiments, effort was made to obtain a representative sample of the general school population. Since the age range of the first to ninth grades was to be covered, it was necessary to take subjects from more than one school, but

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[1] The standardizing experiments and the preparation of the manuscript describing them are the work of M S Card. The procedure in question was organized by F. L Wells who also cooperated editorially concerning the manuscript, and added the paragraphs pertaining to reading difficulty cases

the two schools chosen were both public schools and located near to one another; their student bodies were considered as similar and as nearly typical as could be found with respect to distributions of wealth, nationalities, and intelligence.

The limitations of the experiment set the number of subjects at approximately 250; there were five groups in each of which were at least 50 children. Each group was composed of pupils from one of the odd-numbered grades from the first grade through the ninth. It seemed desirable to include the whole grade whenever practicable and this was done in the first, third, and fifth grades, making the numbers in those groups slightly higher. In the seventh and ninth grades, where selection was necessary, it was in each case done in a way to preserve the intelligence distribution of the whole grade.

The number of cases and their grade distributions were 56, 53, 61, 60, and 55 in the first, third, fifth, seventh, and ninth grades respectively, making a total of 285 cases actually used.

Mental age ratings were obtained through the courtesy of the public school officials and were based almost entirely on group tests given every three years. The school program of testing does not permit more frequent regular examination of any one group and individual tests are not usually possible. Although nearly all the subjects had been tested within a year of the date of this experiment, the mental age ratings used are less reliable than desired, but it was not possible to trespass further upon the school time in order to secure others.

MATERIALS

The materials for this test are readily available; most are to be found among the usual office supplies and reasonable skill in office techniques is all that is required to assemble them. The first subtest utilized a set of commonly seen objects, the others are typed or mounted on standard 3"x5" cards, which are most conveniently placed in a Kardex or Rand visible index holder. A small-size holder gives space for alternate series since there are only nine cards. Any card in it is easily selected and exposed to clear view and is automatically put out of sight when the experimenter turns to another. If a protective covering is desired for individual cards, pieces of cellophane or some similar transparent substance can be placed over them.

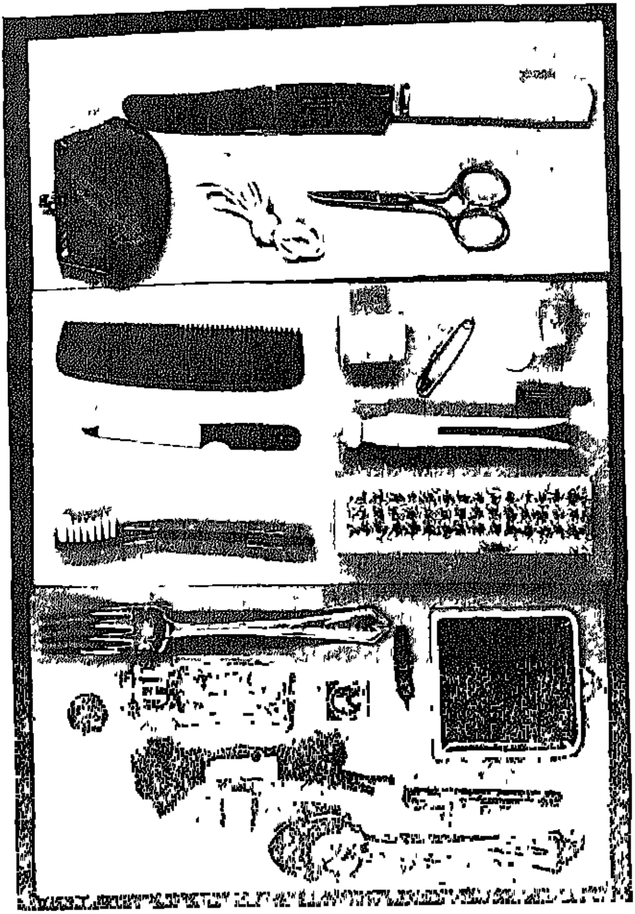

FIGURE 1

Subtest 1, Naming Actual Objects. A collection of 24 well-known objects listed below and illustrated in Figure 1 is needed for this test. They should be the articles as used and seen in everyday life, the familiar sizes and designs, not miniature replicas or unusual types. The essential point is that all should be easily recognized. This should be kept in mind in the assembling and also in the arrangement.

It is advisable to mount the collection in some way but the means of doing this must not render identification difficult. Transparent gummed tape or a strong glue like LePage's or Duco waterproof cement is recommended. In this experiment the objects were fastened on three separate cards of approximately 6"x11" each as they were found easy to transport. Ease of recognition is again considered in the space allowed between objects.

Maintenance of equal difficulty in naming is assisted by ordering the various items so that associations between those which are adjacent shall play the minimum part in the naming process; the brush will not be next to the comb or toothbrush for instance, nor the screw beside the nail.

List of 24 actual objects

brush
fork
toothbrush
bottle
knife
spoon
scissors
pocket-book
shoestring
screw
mirror
spool
file
comb
clothespin
penny
thimble
stamp
cork
string
pen
nail
safety-pin
button

Subtest 2. Naming Colors. This test, illustrated in Figure 2, utilizes 40 Dennison ¼" gummed dots. There are ten of each of the four colors, all in four rows and ten to a row. The orange, green, blue, and red discs are arranged within the rows so that no three of the same color are together and every color appears in each row. Orange was used here because yellow was not available. This probably widens the gap between the colors and the color words, where yellow is used.

Subtest 3. Naming Digits. The card for this test is shown, out of the holder, together with those for all the succeeding tests, in Figure 3.

The digits, 0 to 9 inclusive, are typed on one row in a chance order which is reversed in the next; they are in another chance order in the third line, it being reversed to make a fourth.

Subtest 4. Naming Lower Case Letters. The letters of the alphabet, in chance order, are in two rows of lower case typing. A third row repeats the letters of the second but in reverse sequence, and a fourth does the same with those of Row 1.

Subtest 5. Naming Upper Case Letters. This test is made up in the same way with the letters in a new order and typed in capitals.

Subtest 6. Naming Pictures. Ten pictures, in this instance, from

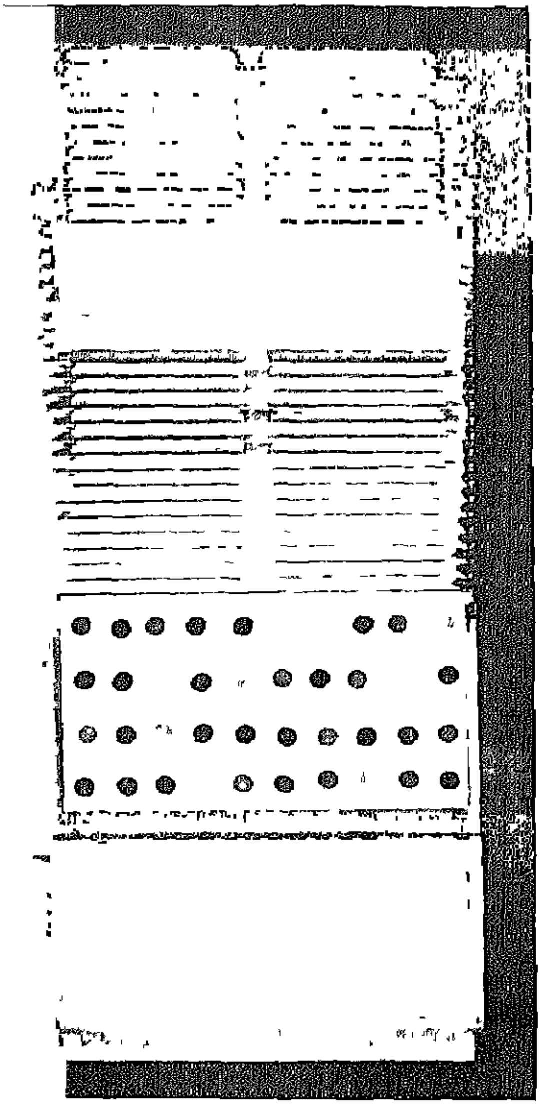

FIGURE 2

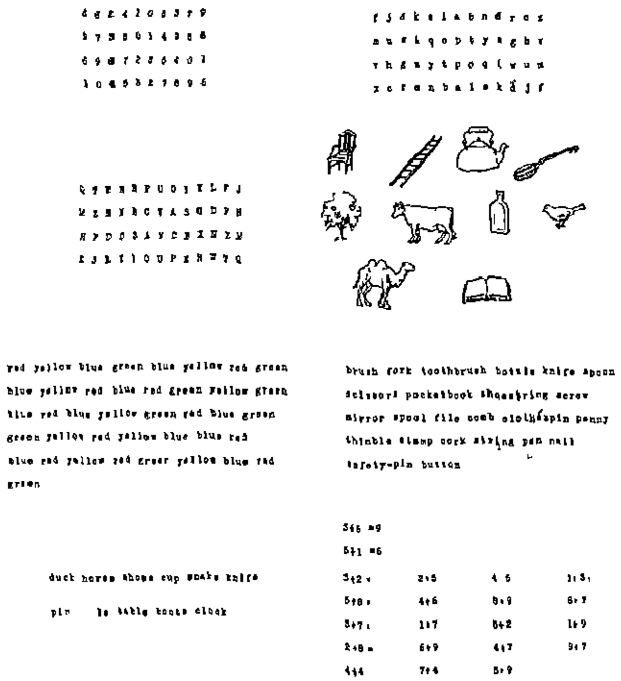
red yellow blue green blue yellow red green
blue yellow red blue red green yellow green
blue red blue yellow green red blue green
green yellow red yellow blue blue red
blue red yellow red green yellow blue red
green
brush fork toothbrush bottle knife spoon
scissors pocketbook shoestring screw
mirror spool file comb clothespin penny
thimble stamp cork string pen nail
safety-pin button
duck horse shoes cup snake knife
pin le table boots clock
3+6 =9
5+1 =6
3+2
2+5
4 6
1+3
5+8
4+6
8+9
8+7
3+7
1+7
6+2
1+9
2+8
6+9
4+7
9+7
4+4
7+4
5+9

FIGURE 3

the third page of the Myers Mental Measure, by Caroline and Garry C Myers (Chicago, Newson, 1921, used by permission) are mounted on a card as shown in Figure 3 The subjects illustrated in one series are a chair, ladder, kettle, banjo, tree, cow, bottle, bird, camel, and book

Subtest 7 Naming Color Words The words "red," "yellow," "green," and "blue" are treated in this test as were the colored dots in Test 2 Each is repeated ten times but never more than twice in succession Lower case typing is used exclusively

Subtest 8 Naming Actual Object Words The names of the actual objects presented in Test 1 and listed above comprise this test Again only lower case typing is used and the words follow one another in lines as shown in the plate

Subtest 9 Naming Picture Object Words Ten words equivalent in difficulty to those used as names of the picture objects in Test 6 are the material of this test.

Subtest 10: Addition Twenty sums in simple addition make up this test. They are preceded by two illustrative examples to which the answers are given

PROCEDURE

The brevity of these tests and short periods of time utilized make it desirable to observe special precision in all matters affecting this time element. Any close observation of the material or preliminary study of it is to be avoided with particular care, the procedures which determine such opportunities should be carefully standardized and exposure of the material, previous to the timed performance, restricted to the necessary minimum

For this reason, it is advisable to describe the nature of the task in advance, saying, for example, "Now I am going to show you some pictures and ask you to tell me the names of the things you see," before allowing the subject to look at all. When the sentence has been spoken, or during its closing words, the examiner may turn to the proper card with the words, "Now go ahead and tell me as fast as you can what you see there," or simply, "Go ahead now." In this manner, one can successfully synchronize the beginning of the timed test performance with the first view of the test material. While the proper moment to start the stopwatch cannot be stated exactly, it can, in most cases, follow very closely, or be coincident with, the display of the material.

While speed should not be stressed so that the emphasis has a detrimental effect upon other aspects of the performance, the significance attributed to time scores obviously calls for attainment of a maximal speed of response. Furthermore, subjects who might regard the tests as childish and uninteresting are often aroused to exert themselves to the utmost by the idea of a speed test.

The recording and classification of responses is described in detail in the procedure for Subtest 1 and should be observed throughout the series; the special questions raised in tests involving repetition of stimulus are discussed in connection with the giving of Subtest 2 and all said there applies in other tests similar to it in this respect; the procedures of all similar or obviously comparable tests should be considered together—that for upper case with that for lower case letters, Name Actual Object Words with Naming Actual Objects, Naming Colors with Naming Color Words, etc.

Errors or unusual responses are recorded and their source noted whenever it can be determined; as carelessness, poor visual discrimination, perseveration, a tendency to make reversals, etc.

Subtest 1. Naming Actual Objects The display of actual objects is arranged at the edge of a desk or table where the child can see it all plainly and without effort.

Examiner: "Now I am going to show you some things I have here and as I point to each one you will tell me the name as quickly as you can."

All being in readiness, the first object is indicated, the examiner saying, "Tell me what this is." "What is the name of this?" or "What do you call this?" More explanation is rarely needed than that given above and pointing alone usually suffices to bring forth the names of the other objects.

While there is no set order of naming, it is well to have a regular sequence, preferably one which seems most natural—across from left to right or by groups, according to the particular arrangement of objects

There must be no delay in indicating the next object if the total time scored is to be truly that required by the process of recall. On the other hand, the move must not be made so soon as to be confusing. *In general, the good moment is during the enunciation of* the name; provided, of course, the name spoken is, or promises to be, acceptable as correct

If the word given by the subject is not one which can be considered correct for the object designated, the examiner continues pointing to the misnamed article with care, however, to observe the time limit involved. The error may be corrected without anything's being said by the examiner, or assistance may be necessary. Such assistance should be confined to remarks or questions which will aid the child's realization of being in error, remarks such as "Think of some other name," or such queries as "What else is it called?" Supposing the word "brush" has been given as the name of the toothbrush, the inadequacy of this may be indicated by asking what kind of a brush, lack of precision will be penalized in the time score, since the watch runs continuously, yet it will not be mistaken for ignorance.

The object of the test is to determine the total time required by the given subject for the recall of the names associated with this set of articles, *and thus the name sought is the one naturally used* by the given individual, the one which his experience connects with the thing designated. Responses are to be considerately judged in this light and not merely as if this were a vocabulary test; "pencil" *should not be accepted for the stimulus, pen, for that is an object* correctly named in all normal experience, but "bobbin" might be a satisfactory response to the spool from a textile worker's child An inquiry as to what the thing in question is called at home may be *made at the end of the test and it usually serves to settle the status* of the offered name. But a tentative decision at least must be made at once, for these special facts cannot very well be brought out until later

*A satisfactory name is obtained within five seconds or the cor*rect one is supplied at the end of that period, more than five seconds is never to be spent in seeking a correct response to any one stimulus. This is a limit set in all the tests, a maximum of five seconds for any *one item*

On the completion of each of the ten tests, the total time required for its performance is noted in the space provided on the test blank; unusual responses are recorded in the margin in the manner to be described. Those classified as errors are counted and the total entered in the appropriate space on the test blank. Stimulus and response are written, stimulus first always, in this way: horse = house. Three types of mistaken responses are recognized and variously distinguished in the recording These types and their notation are as follows:

1. The spontaneously corrected response which is underscored

$$\text{horse} = \underline{\text{house}}$$

*An entry of this sort records a mistake which the subject cor*rects entirely of his own accord without either suggestion or assistance of any kind from the examiner. This type of response is not counted as an error.

2. *Erroneous responses, not spontaneously corrected, denoted* by simple recording,

horse = house.

This simple recording indicates an error which the subject does not appreciate as such himself but which he is able to correct once the examiner has in some way shown that a mistake has been made. The correction must be made without further assistance than indication of the fact of being in error and it must be forthcoming within five seconds if the response is to be in this category.

Responses of this kind are counted as errors because some assistance is required although it may be no more than a significant delay in the procedure.

3. Failures, a stimulus to which there is no response and all errors which cannot be self-corrected, are entered with a line drawn around them (encircled or "ringed").

The name of the stimulus appears alone within the encircling line if no response has been made to it; any response made is encircled with the stimulus All mistakes requiring specific assistance for their correction are thus recorded. Attention should be paid to the proportion of these corrected and uncorrected errors.

Subtest 2· Naming Colors. For this test and for those following it, the subject was comfortably seated at a desk or table with the Kardex holder laid before him.

The examiner says, "Now I am going to show you some colors and you will tell me their names as fast as you can " Opening to the card, he continues, "You will go right along by yourself " It is well to move a pencil across the card below the first line while speaking, to emphasize that the performance is to continue as though the colors were read from print. The signal to begin the test can usually follow at once

While the pointing procedure in naming the objects may be recalled, leading to expectation of something similar here, it is preferable to confine oneself to the explanation given above until its inadequacy is plainly shown in the test, for more is rarely necessary and is likely to be confusing as well as superfluous. If a repetition of the pointing to each stimulus is expected, that fact is usually evident at once so that it is quite permissible to stop, say whatever may be required, and then recommence.

Both the procedure and the material of this test raise questions in regard to errors. first, as to informing the subject of his having made a wrong response and, second, concerning the counting of errors when the same stimulus is presented more than once, that is, when there is opportunity for repetition of mistakes. This is the case here and in the Naming Color Words as well as in three other tests, the ones in which digits, upper case, and lower case letters are respectively named.

On the whole it seems advisable to avoid interruption as much as possible, waiting until the end of the test or until there is some momentary pause as at the end of a line. The decision depends largely on *the number of mistakes made. If they are not too* numerous, one can allow the subsequent appearance of the stimulus in question to provide the opportunity for self-correction; this is preferable but when there are many mistakes it may be difficult. *Each persistent error is pointed out and up to five seconds allowed* for its correction as in the naming of the objects An understanding of the counting of errors where there is duplication in the material will show the logic of this procedure.

A given combination of stimulus and response is not scored as more than one error, regardless of repetitions If "yellow" is the response to the stimulus "green" it is scored as one error whether said once and later corrected or said consistently, all greens being called yellow. *However, for another stimulus,* "blue" *for example, to be* misnamed "yellow" there would be another error counted. It is the persistence of a given combination which brings no added penalty.

Subtest 3. Naming Digits Turning to the next card, the examiner says, "Now, I am going to ask you to read some numbers." If there are no questions when the numbers are shown the child is told, "Go ahead as quickly as you can Tell me the name of each number."

Subtest 4: Naming Lower Case Letters. The examiner says, "Now, I am going to ask you to tell me the names of some letters," and shows the card of lower case letters. It is well to stress the "letters," with younger subjects at least, since this test follows one of reading digits. All being understood, one may indicate that the test is to begin with the words, "Now, tell me the names of these letters," "Read these letters for me."

Subtest 5: Naming Upper Case Letters. Turning to the card for this test, the examiner says, "Now, tell me the names of these capital letters," stressing slightly the word "capital." The subject can usually begin at once without further directions. If he starts to say "capital" before each letter, he may be stopped at once, told that it is not necessary, and allowed to begin again without penalty. It is advisable to risk the occurrence of this rather than to specify omission. Only a small proportion of subjects attempt to put in the word and to speak of it may confuse a child unnecessarily.

Subtest 6. Naming of Picture Objects. This test is comparable to naming the actual objects and the procedure is the same except that there is ordinarily no pointing

Here, especially, it is well to speak before presenting the test card, saying, "Now, I am going to show you some pictures," and adding, as they are exposed, "Tell me what you see," or "Tell me the names of the things in the pictures as quickly as you can"

It is usually done by naming from left to right Exception to this order may be noted on the test blank but need not be mentioned to the subject.

Subtest 7 Naming Color Words. Turning to the card for this test, the examiner says, "Now, how quickly can you read these words?"

In giving this test one should refer to the suggested procedure for naming the colors, of which this is a verbal counterpart

Subtest 8· Naming of Actual-Object Words. This card is presented and the subject told to read these words as quickly as he can.

Since this test is composed of a number of words, none of which are repeated, the recording of errors is facilitated by the examiner's having a duplicate, with each word given a number which will serve as a key to that word. The numbers may be put down more quickly than the stimulus words they represent, so leaving more time, also space, for notation of wrong responses If the performance on previous tests makes it likely that there will be many mistakes and consequently much to write, it may be well to turn at once to the reverse and blank side of the record sheet where there will be ample space for the desirable full recording.

Subtest 9: Naming Picture-Object Words. The procedure is like that for the preceding test and a low level of reading ability makes the same suggestions applicable.

Subtest 10: Addition. The examiner says, "Now I am going to ask you to do some addition for me, to add some numbers together for me as quickly as you can." Showing the card and pointing to the two illustrative examples, he continues, "It is all addition like this" Emphasis that the process required is addition is recommended as there is some tendency to multiply the digits instead of adding them. The child is allowed to look at the samples, reading them aloud or not as he chooses. Then, indicating the first example in the test proper, the examiner says, "Now begin here and tell me the answers. Go ahead"

If the child asks whether to read it all aloud or only the answers, the reply is, "Whatever way you wish," and there is to be no comment made if there is a change of procedure during the test. It is also insignificant whether the sequence is by columns or rows, but the former is more usual. It is convenient for the examiner to have a duplicate card on which to follow the subject's performance.

In this experiment, the procedure in the Addition Test, Subtest 10, was such that the answers were given orally and the reading of the digits representing the quantities to be summated was also oral. The examiner felt that the procedure would be better standardized if all the performance was oral in all cases A question was raised as to the inhibiting effect of this procedure upon a subject whose habit patterns (silent addition) would make this oral performance unnatural and would thus adversely affect his score An alternative generally followed by Wells allowed either oral or silent reading of the digits on the card and required only the answers to be said aloud. The results were considered comparable because the time required for the mental processes involved in obtaining the answer was not thought to be increased by the verbalization incidental to oral reading of the given figures, and more representative of the subject's ability because there was the minimum interference with normal behavior

While no statistically significant data have been obtained, administration of this subtest to a group of 61 children from the second, fourth, and sixth grades brought out the following facts: oral performance was preferable to two-thirds of these children; the median score for the voluntarily silent performance was definitely lower than that for the voluntarily oral performance when the medians for all silent and oral scores were taken, and the same tendency was shown for the grade medians The tendency to verbalize was so marked in this group that any adverse effect of a required oral reading could not be estimated. Second trials were asked of some subjects specifying the oral reading from those who had preferred the silent and vice versa, the silent scores of these trials were consistently better than the second trial oral scores and, while the second trial was always done in less time when it represented a silent performance, even practice effect failed to make the second trial oral scores of some cases as good as their first trial silent scores. In these cases the interfering effect of following the rejected procedure may have been a factor.

No conclusions may be drawn from the small number of observations made; the possible detrimental effect of requiring a somewhat abnormal procedure is not disposed of; it is seen that the speed of those who preferred to verbalize averaged lower than that of those who chose to read silently, but the difference, assuming it valid, may be due to the delay caused by the verbalization or to the fact that those with the slower mental processes were also those who preferred it.

With respect to the results of the experiment proper, it is likely that the time scores made at the upper grade levels were less good because of this requirement and the median scores at the seventh and ninth grade levels may be higher than would have been the case had there been a choice of procedure; there is probably little if any effect at the lower levels, where it is possible that the suggested verbalization was actually of assistance, especially to the less proficient, and thus served to improve the speed.

RESULTS

1. Quantitative Statement. The time scores made by each grade group on each of the ten subtests were arranged in a series of frequency distributions, and the median scores found and tabulated as shown in Table 1. As the more convenient arrangement for reference, the results are presented with the median scores of each grade

TABLE 1

MEDIAN TIME SCORES

	Grades				
Tests	I	III	V	VII	IX
Naming Actual Objects	66	50	44	35	33
Naming Colors	42	38	29	26	23
Naming Digits	45	24	17	14	14
Naming Letters, lower case	78	41	29	22	19
Naming Letters, upper case	64	37	28	24	21
Naming Picture-Objects	17	12	11	8	8
Naming Color Words	47	24	20	16	15
Naming Actual-Object Words	—	30	18	14	12
Naming Picture-Object Words	54	7	5	4	4
Addition	—	49	34	26	26

in a separate column, the order within the column being that of the test series.

Four sets of ratios were computed between the time scores in pairs of corresponding subtests; these ratios were arranged in frequency distributions and the medians found for each subtest at each grade level. The results *shown in* Table 2 are comparable to those in Table 1, giving the median time scores.

TABLE 2
MEDIAN RATIOS

Time scores in naming	Grades I	III	V	VII	IX
Lower case letters/ *upper case letters*	1.26	1.13	1.03	.96	.95
color words/colors	*1.15*	*.66*	*.66*	*.68*	*.68*
actual-object words/ actual objects	—	.59	.42	.41	.39
picture words/ naming pictures	3.85	.64	.55	.53	.50

From observation of this table it may be seen that the time required for the naming of lower case letters is relatively long for the lower grade and short for the upper, i.e., there is a relatively greater familiarity with capital letters on the part of the young child which decreases until it disappears at about the fifth-grade level when the response is nearly the same for either, after the fifth grade the lower case letters are read more rapidly but the difference evident in the seventh grade is not significantly changed by the ninth so it presumably holds constant at higher levels.

In all comparisons of reading with naming, the recognition of the word is shown to occur more quickly than that of the object, picture, or color except at the low level of reading skill found in the first grade, i.e., there is a more prompt association between a word and its representation in print than between that word and the thing of which it is a symbol. This fact is more clearly set forth at each level; as one goes higher in the scale, speed in naming the actual-object words increases more rapidly than speed in naming the objects and the same is true of the pictures. The failure of this tendency to manifest itself above the third grade with respect to colors may be explained by the fact that the reading and naming in these subtests were so simple, involving only the four color-words and colors, that the results above the third grade are determined mainly by physiological limitations.

Correlations were calculated between the mental age ratings and time scores in naming actual objects. A significant relationship between speed of naming objects and intelligence was shown in a coefficient of +.49±.07 for the ninth grade. While virtually the same for the seventh grade and still significant in the first grade (.35±.08), the results in the other grades were too low to be significant. Although the unreliability of the mental age ratings was a factor, the nature of the tests and the brief periods of time involved are such that there is little opportunity for quantitative differentiation adequate for purposes of correlation. While some correlations with mental age were calculated for the speed in naming colors and also for certain ratios, no significant figures were obtained.

The number of errors was not sufficient to warrant making frequency distributions of errors above the third grade. However, the median number of errors for each subject in the first and third grades is as given in Table 3.

TABLE 3

MEDIAN NUMBER OF ERRORS

	Subtest number									
	1	2	3	4	5	6	7	8	9	10
Grade I	2½	0	1	5	3	1	0	—	5	—
Grade III	0	0	0	1	0	0	0	1	0	0

Subtests 8 and 10 were failed by more than half of the first grade.

2. *Qualitative Analysis.* An analysis of responses given in each test follows to show the unusual and erroneous responses which may be expected.

Subtest 1: Naming Actual Objects. In the list of objects and names given, the most common and accepted name of the object will be in upper case type. If an alternative name generally considered acceptable is given, it will immediately follow in parentheses in lower case type. Then follows the list of names usually classified as errors. Numbers immediately following the name of the stimulus show the total number of errors for that stimulus; frequencies of 1 are not indicated numerically in the list of errors. The sum total of all errors made in naming these objects is 288.

List of Actual Objects and names supplied by subject:

BOTTLE 7 glass 3; jar 3, water
BRUSH 2 scrub *floor with*, refusal
BUTTON 0
CLOTHESPIN 20 clothes, clothespole; clothes, you hang 'em with; hang 'em on line, pin, refusals 15.
COMB 3: brush 2; refusal.
CORK 24 (stopper 6), cap, cokker, cord; cover 2; hoik, pork, top 6; refusals 11
FORK 4 knife, spoon 2, refusal
KNIFE 0
MIRROR 4 (looking glass), glass, refusal 3
NAIL 1 can't think
NAIL-FILE 30 (finger nail cleaner); filer, finger 2, finger nail 12, finger nail thing, nail; nail thing; manicure, refusal 11.
PEN POINT 13 (pen; ink pen, thing for pen; thing put [or goes] in pen), ink, ink holder, pen holder, pin, point for pencil, thing you write with, refusal 7
PENNY 0 (cent)
POCKETBOOK 0 (purse, small bag; if design makes this last *appropriate)*
SAFETY-PIN 6 (pin*, common pin* 5; big pin*; diaper pin), *cut pin*, *needle pin*, *refusal* 4
SCISSORS 0
SCREW 45 *nail 37*, *nut*, *tack*, *refusal 4*.
SHOESTRING 7 (shoelace, shoelacing), lace 2, string 4, thread
SPOOL 62 (thread spool, cotton reel**, spindle** 2, thread spinner**); cotton 2, thimble 7, put thread on, thing to put thread on 8, thing your thread goes round, thing thread on 2, thread 3, thread thing 4, to roll thread on; thing you have string on, thing for string, refusal 31
SPOON 1: refusal
STAMP 4. refusal 4
STRING 16 thread 7, rope 8, refusal
THIMBLE 30 (nimble** 4), cup, cork, finger, spindle; put on when you sew, put on your finger, thing you put on your finger 2; thumb 2, refusal 20

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*Not counted as an error if question "What kind of pin?" brings forth the word "safety-pin"

**Not counted as error if it seems the name most familiar in subject's environment

TOOTHBRUSH 11: brush 5; brush, red; cleaning brush, thing you brush your teeth with 2, refusal.

Table 4 states the frequency of errors by grades.

TABLE 4

Grade	Errors	Percentage
9	25	1.89
7	45	3.12
5	29	1.93
3	38	2.92
1	151	11.24
Total	288	

Subtest 2: Naming Colors The greatest significance of errors made in this test is not revealed in any quantitative statement, for there was little relationship between number of errors and grade level; it lies rather in their apparent source, in the poor visual discrimination made evident, etc. It is important to note if certain hues are consistently misnamed; which ones, if that be the case, and the relation of the name supplied in the response to the correct one. Poor reading habits may be manifest in reversals, omissions, and inability to keep the place in line.

Subtest 3: Naming Digits.

1 once as 6, never refused, total errors, 1.
1 once as 6, never refused; total errors, 1
2 once as 5, as 7, and as 4, once refused; total, 4
3 once as 5, twice as 6, twice refused, total, 5.
4 not misread but twice refused, total, 2.
5 once as 6, once as 4, refused four times; total, 6
6 five times as 9, refused six times; total, 11.
7 once each as k, 4, 9, twice as 6, 8, and 10, refused five times; total, 14.
8 four times as 7, once as 10, refused four times; total, 9
9 seven times as 6, twice as 8, once as 10, refused six times; total, 16.

The sum total of all errors was 76, of which 73 were made by the first grade; the other three were by third-grade subjects. In the third grade were also three omissions due to carelessness alone; in the fifth grade, the only errors were three reversals made by two children; there was one omission in the seventh grade; there were no mistakes of any kind in the ninth grade.

Subtest 4: Naming Lower Case Letters The number of errors and the misreadings were fully recorded in all grades except the first in which the mistakes were often too numerous for it to be feasible to do more than note the stimulus letter causing the error It was, however, thought worthwhile to summarize the observations made even though the record of responses is thus less complete in the lowest grade.

TABLE 5

Stimulus	Misreadings Figures show frequencies above 1	Refusals and unspecified misreadings	Total
a		0	0
b	d 12, p 4	3	19
c	e 2, g; k 2; s; z	1	8
d	a 10; b 4	10	24
e	u	0	1
f	r 3	1	4
g	d; l 2, q; y	2	7
h	f, n; u; v	5	9
i	x	8	9
j	g 23, h; i	6	31
k		3	3
l	i 71	4	75
m	n 2,	0	2
n	d; u 4	4	9
o	u 3	0	3
p	b; d 2, q 6, r	7	17
q	b, g 2, j, k 2; o, p 23	36	66
r		1	1
s	a 2, o 6	1	9
t		1	1
u	q 2	5	7
v	f, y 2	8	11
w	y 2	1	3
x	y; z 2	13	16
y	l 2, k; s, u 5; w	2	12
z	c, s, v, x 7	18	28
		Total	375

Frequencies, by grades, are shown in Table 6

TABLE 6

Grade	Errors	Percentage chances
9	6	0 2
7	12	0 38
5	32	1.0
3	94	3 4
1	231 (omitting 5 cases)	8 7

The number of cases is complete in all grades except the first in which five of the group of 56 failed so completely that their performance is not counted at all

Subtest 5· Naming Upper Case Letters The recording and tabular presentation of responses is the same in this test as in the preceding one

TABLE 7

Stimulus	Misreadings Figures show frequencies above 1	Refusals	Total
A		0	0
B	P 2	2	4
C		4	4
D		4	4
E	F 2	2	4
F	E 6, I 2, P	3	12
G	V	4	5
H	E, G	3	5
I	L 2	0	2
J	G 10	4	14
K	X 5	4	9
L	I; K	7	9
M	W	1	2
N	E	6	7
O	Q, W	0	2
P	Q; B; G	1	4
Q	O 4, U 4, X 2, Z 3	18	31
R		5	5
S	C 2, H; U	1	5
T		5	5
U	W 2	2	4
V	F; W 2; X, Z	7	12
W	U, Y	1	3
X	Q; V, Z 3	7	13
Y	U 6; W	2	9
Z	V, Z 9	15	25
		Total	198

Frequencies by grades are as given in Table 8

TABLE 8

Grade	Errors	Percentage
9	10	4
7	7	.2
5	9	.3
3	29	1 1
1	143 (omitting 7 cases)	5 6

Here, as in the preceding test, seven of the first grade failed so many letters that no regard is paid to their performance.

Subtest 6: Naming Picture-Objects. The listing of errors here is the same as that for subtest 1 The sum total of errors is 76

CHAIR 1: house
LADDER 1 refusal
KETTLE 19: (pot 4, coffee pot 3, tea pot) China; coffee pan; hot water bottle, pan; pitcher 3, refusal 12
BANJO 41· (fiddle, guitar; banjo, mandolin, ukulele, violin) Ban; banjolin, brush 4; hair brush 2, strainer; play it with a little thing, you play on it 2, refusal 29
TREE 0.
COW 1 pony.
BOTTLE 1 milk
BIRD 0: (canary bird; chick, chicken, pigeon)
CAMEL 12 cambra, donkey, goat, sheep; refusal 8.
BOOK 0.

The total frequency of errors in each of the different grades was as shown in Table 9

TABLE 9

Grade	Errors	Percentage
9	6	1.1
7	6	1.0
5	6	1.0
3	13	2.5
1	45	8.0

Subtest 7: Naming Color Words. No special study was made of the errors occurring in this test and there seems no pertinent comment except the frequency of the response "orange" to the word stimulus "yellow" This is presumably explained by the use of the orange color dots in the test in naming colors; it is a good example of underanalysis

The use of only four words and their familiarity as well as their frequent repetition means that the demands of this test are different from those of Tests 8 and 9 and merit consideration on this account. It requires the least vocabulary and reading knowledge and so provides an especially favorable opportunity for detection of faulty reading habits and certain poor eye movements, for most subjects, this is very easy material and thus offers them a chance to show what they can do when the content presents little or no difficulty.

Subtest 8: Naming Actual-Object Words. The responses for these words are listed in the same manner as those for the actual objects; each of the stimulus words in upper case type, here presented in the reading order, is followed by the list of responses made to it, frequencies of two or more are indicated by the appropriate digit. The sum total of errors is 395.

While certain responses may resemble the correct reading so closely that they seem wrongly listed among the errors, they were given without comprehension and did not suggest the stimulus object name even though they sounded very much like it. Neologisms are spelled so as to most nearly represent their sound.

BRUSH 15: best; blue, brown; bush 8, push; refusal 3
FORK 11: fog; fok 3, foks, folk 2; fore, work; refusal 2
TOOTHBRUSH 21: too- 5; toots, tooth-, toothpaste 4; toothpick 5; refusal 5.
BOTTLE 13: birs; bootle, botle; both, broom, buttle; little; *refusal 6.*
KNIFE 13: k-, ki, niff; refusal 10.
SPOON 3: refusal, 3.
SCISSORS 28 circus; saucer 5; skizors; thimble; refusal, 20
POCKETBOOK 18: -book; book-puck, pickbook, po-, po-book, pock; pocket; pocket knife, pu-book; puckbook; refusal, 8.
SHOESTRING 21; show 2, shoes, shoelace 3, shoeshine; shoestitching; shoe-ting, shortstring; refusal, 11
SCREW 30: s 2; scarf; scre-, sew; speel 2, store; string; *refusal, 21.*
MIRROR 21. madre, mail; meyer; miror; narrow; needle; refusal, 15.
SPOOL 16: screw; spoon 11; refusal, 4.
FILE 31: f-; fail; felt, fiddle 2; fill 12; finger, fork; kni-; knife 2; light; thimble 2; refusal, 6
COMB 15. camp; cu; cub; cumb 3; refusal, 9
CLOTHESPIN 22. cl-; clo-; cloth; clothshim, clothspin 4; clothesplint; safety-pin; refusal, 12.
PENNY 5. pin 2; pony; spin; refusal
THIMBLE 13: *tablet, toothbr-, refusal, 11.*
STAMP 11: spool 2; spoon; stopper, string, refusal, 6.
CORK 18. c- 2, clock; color, corn 2, crack, crook 2; fork; lark; quirk; *refusal, 6.*

STRING 17 (and 2. See "Pen") pin, st- 2; staing, strap, stringing; thimble; refusal, 10

PEN 11: penny 3, pin 4; pocketbook; refusal; steering pen, straining pen (1 each, reading "string" and "pen" together).

NAIL 10 knife, nile, needle 2; mirror, pencil; refusal, 4.

BUTTON 21 blue-, bottle 6, bottom 5, but- 2; butter 2; buttern, butts; refusal, 3

SAFETY-PIN 10 safety-pain; spoon penny, refusal, 8

The number of errors by grades is given in Table 10

TABLE 10

Grade	Errors	Percentage
9	12	.09
7	17	1.2
5	52	3.6
3	181	14.0
1	133 in a group of only 8 highly selected subjects	(69.5)

Subtest 9: Naming Picture Words These words and the responses are listed as were those for the preceding test

DUCK 14 back 2; black 7, clock, d—, track; refusal 2

HORSE 42. brown, day; hen, house 21, home 6, norse, refusal, 11.

SHOES 46 elephant, home, pony, sharp; sheep 3, shell, shill, shirt; show 3, shown, shows 2, sleepy 2; sores 2, swim; refusal, 25

CUP 21 can, cat 3, club, could; cry 2, cut 4, hop; out, pen; put 2; refusal, 4.

SNAKE 50: black, nail, saucer, shake 12, skate 2, sn- ; sn—k , snail 4; stick; take, refusal, 25.

KNIFE 50: calf; cake 2; cut, k—2; kind; kine, kitten; pussy[2]; refusal, 40

PINEAPPLE 63 apple 2, p— 3, pen, penny; people, picture; pimple, pinapple 8, pinappron, pitcher, plece; pole; pocketbook, porkapple, porridge, potato; spoon, refusal, 36

TABLE 14 cake, chair; take 2; tape; tartre, tell; toad; refusal, 6

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[2] This special type of error is further discussed in Wells (1), which study also includes some of the reading difficulty cases mentioned below

BOOTS 49: b-, bake; back, bath; boats 3, boods, book 3; books 9, bookcase, box; boys 3, brook, burnts, buts, chair, foot; hot, put, refusal, 17.

CLOCK 36: cake; candy; chair, cl— 3, cloak 3, clothes, cock, color; cook, cord; cut; goose, kind, six, table; watch pick; refusal, 16.

The number of errors by grades is indicated in Table 11

TABLE 11

Grade	Errors	Percentage
9	1	0.2
7	4	0.7
5	6	1.0
3	34	6.4
1	340	60.1
	Total 385	

Subtest 10. Addition. No analysis was made of the errors in this test except to note whether the cause was due to a mistake in addition or to use of the wrong process, i.e., to use of multiplication.

Reading Difficulties

It is hoped that, through studies such as these, attention may be directed to the relation between the symbolic processes involved in reading and that of other naming processes. The test itself has found various clinical applications, particularly to aphasic symptoms The normal child controls the vocal symbol for the printed word far better than he does that for the corresponding common object In a less degree the same is true for pictures of objects, and for colors. The extent of a child's specific reading difficulty is to be measured by the distortion of these normal relationships. At fifth grade, for example, he should be able to name the words for the present colors in about two-thirds the time of naming similarly presented colors themselves. Insofar as it takes him longer than this there is specific reading difficulty, that is to say a difficulty in the perception of a graphic language symbol. In the present case the criterion of perception is the production of the corresponding vocal symbol, the likelihood that a child would know what such a printed word denoted and not be able to call it by name, or vice versa, need hardly be considered in this connection "Reading tests" in general tend to be tests of reading as such, without direct reference to other language functions, as is here attempted

For the child with a reading problem the tasks are, as will be seen, often too difficult to be satisfactorily presented in scores comparable with the norm, but this does not greatly interfere in their clinical use, with the more qualitative consideration there afforded. Below is given a tabulation of certain results with the procedures in ten children (all boys) who had been referred for reading difficulties. Cases A and B are identical twins The "normal scores" for the even grades are taken as midway between those for the experimentally determined odd ones When a score represents the time limit of a test (five seconds for each reply) it is put in italics. The true value is then indefinitely greater.

The greatest disparity is seen with the "picture objects." In general a child with reading difficulty names the pictures more readily than do the normal controls, sometimes much more readily. Only two of them could read the words, if at all, within the time limit involved, whereas after the third grade the normal reading score is about half that for naming the pictures.

The naming of objects proceeds somewhat better than the norm for the grade, this being marked in cases where the child is old for his grade. The difficulty is not a mild "sensory aphasia" but rather a specific, if mild, alexia. The normal child reads the names of these objects in about half the time it takes him to name the objects themselves (cultural verbalization, cf. Trigant Burrow). The child with a reading problem takes indefinitely longer, failures to read being very frequent, so that again but two of these children completed the series within the time limit involved.

In naming colors the reading-problem child as here observed ran uniformly slower than the normal control; the symbolic process approaches more closely to that of recognizing a written configuration than it does to the process of naming an object, where he is at no disadvantage The disparity is small but distinct, as is the case also in his difficulty with the color words In third grade and beyond, the average child reads the color words in two-thirds the time of naming the colors The reading-problem child generally also reads the color names more quickly than he names the colors, but at more nearly the same rate than does his normal control

TABLE 12

Case	A	B	C	D	E	F	G	H	I	J
Grade placement at time of test	2-4	2-4	3-8	3-8	4-8	4-3	5-8	5-4	5-6	5-0
Age at time of test	7-2	7-2	10-3	10-11	11-3	11-2	11-2	13-9	10-0	11-4
IQ score (uncorrected for reading) recorded nearest time of test	126	105	89	68	93	85	81	68	106	96
Grade median of reading test scores	2.5	3 0	2 9	1 5	3.2	2 3	3.4	3.6	3 0	4.2
Normal grade score for picture objects	14		12		11		11			
Child's score for picture objects	16	12	7	12	13	9	8	11	8	6
Normal ratio words /picture objects	2.25		65		.60		55			
Child's ratio words /picture objects	3.12	4 15	7.15	4 15	1.92	5.55	6 25	4 55	6.25	4 00
Normal grade score, naming actual objects	58		50		47		44			
Child's score, naming actual objects	65	52	35	39	32	45	47	55	43	52
Normal ratio, words /actual objects	X		59		.50		42			
Child's ratio, words /actual objects	1 85	2.31	3 42	3.07	3 74	2.67	2 55	1 45	2 79	1.09
Normal grade score, naming colors	40		38		33		29			
Child's score, naming colors	47	44	33	40	37	42	58	40	36	53
Normal ratio, words/colors	90		66		.66		66			
Child's ratio, words/colors	1.06	1.04	85	5.00	87	.93	43	.79	.74	70
Normal grade score, upper case letters	50		37		32		28			
Child's score, upper case letters	55	53	59	77	37	77	45	35	34	47
Normal ratio, lower case/upper case	1.19		1 13		1 08		1 03			
Child's ratio, lower case/upper case	.96	.98	1.15	91	1.88	.78	.98	.92	1.03	.81

The normal child apparently learns the upper case letters ahead of the lower case but at about the fifth grade the lower case letters are at least as well known. In the reading-problem child the tendency is for the lower case letters to run rather ahead of the upper case, because *proportionately* more of their reading practice is obtained with them (it is worthy of note that, on the other hand, "educational toys" generally use upper case letters, whereas the overwhelming preponderance of those letters generally used are lower case).

CONCLUSION

The table of median time scores (Table 1) shows a well-graded series of results and indicates that, even in these short tests, time scores provide a satisfactory basis of differentiation. While further experimentation is desirable, using a number of subjects who are reading-disability cases, the use of these scores in the measurement of reading disability is shown in the appended study of ten cases brought to the laboratory at the Boston Psychopathic Hospital

A child may well be considered from the standpoint of reading disability whose facility in naming objects and pictures is at the normal level, while his facility of reading in the equivalent tests deviates markedly and adversely from the corresponding normal figures; the degree of disability being indicated by the amount of deviation from the norms shown in Table 1. Comparison of the ratios for the reading-disability case with those for the normal child of the same school grade may be more striking than comparison of the respective time scores: the relatively slow reading time is further emphasized by a relatively fast naming time and, as in the intelligence quotient, the statement of the relationship, of one factor in terms of another, is often a more appropriate picture of the facts than that given by the absolute figures.

Correlations with such mental age ratings as were available were insignificant except in the case of naming actual objects x mental age.

The number of errors made by the subjects of this experiment, who were chosen as representative of the average school group, was small and warrants little quantitative consideration, but the specific errors were classified to show the relative difficulty of the various test items and the distribution of errors through the grades in each test.

REFERENCE

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LA FORMATION DES SYMBOLES VOCAUX COMME FONCTION DE L'HABILETÉ À LIRE

(Résumé)

Il s'agit surtout de l'habileté relative à symboliser dans la parole parlée (*a*) le mot imprimé, (*b*) un autre représentant ce que dénote le mot imprimé, comme une couleur, un tableau, ou un vrai objet. On a organisé une forme briève d'expérience, adaptée aux attitudes des individus aussi jeunes que l'âge de la première année scolaire. On décrit ceci en détail avec des illustrations. On l'a fait avec une série de 285 individus dans les années scolaires 1, 3, 5, 7, 9. On dérive de ces données une table de normes des années pour chacun des dix tests secondaires en jeu, et de certaines proportions entre eux. On présente les erreurs en quelque détail, pour la lumière qu'elles jettent sur le processus de la lecture comparé avec celui d'autre fonctions de nommer. On présente les résultats avec une petite série de cas de difficulté à lire dans des buts comparatifs, en mesurant leur assez bon rendement moyen quand ils nomment par ex. un objet commun, et leur rendement beaucoup réduit quand ils nomment le mot pour cet objet. Pour le matériel normal, les résultats sont un signe de la verbalisation culturale. Comme repère pour le mot parlé, le mot imprimé est de plus en plus plus efficace que l'objet lui-même.

CARD ET WELLS

STIMMSYMBOLBILDUNG ALS EINE FUNKTION DER LESEFAHIGKEIT

(Referat)

Diese Untersuchung beschäftigt sich hauptsächlich mit der Fähigkeit, die folgenden Sachen in der gesprochenen Rede zu symbolisieren: (*a*) das gedruckte Wort, (*b*) etwas anderes, als was das gedruckte Wort bezeichnet, wie eine Farbe, ein Bild, oder einen wirklichn Gegenstand. Eine kurze Form des Experiments wurde aufgestellt und den Einstellungen von Kindern bis zur untersten Schulstufe angepasst. Dies wird in Detail beschrieben und mit Illustrationen versehen. Das Experiment wurde mit einer Reihe von 285 Personen in der Schulstufen 1, 3, 5, 7, 9 ausgeführt. Eine Tabelle der Stufennormen für jeden der zehn Untertests und gewisser Verhältnisse zwischen ihnen wird aus diesen Daten abgeleitet. Die Irrtümer werden in einigen Detail dargestellt wegen der Beleuchtung, die sie auf das Leseverfahren im Vergleich mit dem von anderen benennenden Funktionen werfen. Die Ergebnisse von einer kleinen Reihe von Leseschwierigkeitsfällen werden zu Vergleichszwecken dargestellt, und ihre Durchschnittsleistung bei der Benennung z B. von einem gewöhnlichen Gegenstand und ihre viel reduzierte Leistung bei der Benennung eines Wortes für jenen Gegenstand werden gemessen. Für das normale Material sind die Ergebnisse ein Zeichen der kulturellen Inwortesetzung. Als ein Fingerzeig für das gesprochene Wort ist das gedruckte Wort fortschreitend wirksamer als der Gegenstand selbst.

CARD UND WELLS

THE RÔLE OF KINAESTHESIS IN THE ESTABLISHMENT AND CONTROL OF THE MAZE HABIT*

From the Psychological Laboratory of The Ohio State University

SOL EVANS

INTRODUCTION

During the first third of the present century there has been considerable discussion of, and no little disagreement on, the rôle that kinaesthesis plays in the establishment and control of the maze habit. W. S Small not only introduced the white rat and the conventional maze into the laboratory, but also raised the problem of sensory control. In 1901 (25) his experimental work with rats led him to conclude that the animal responds in the maze on the basis of tactual-motor processes He held that the animal was able to follow the correct path by associating the *motor image of turning* in *one direction* with success, and the *motor image* of *turning* in the *other direction* with failure He believed that the coordination of proprioceptive processes depends upon kinaesthetic sensations initiated by the turns in the pathway and the relative lengths of the alleys. However, the employment of the doctrine of kinaesthesis as an explanation of the establishment and control of the maze habit dates more specifically from the experiments of Watson in 1907 and of Carr and Watson in 1908.

Watson (31) eliminated sight from one group of rats, hearing from a second group, smell from a third, the vibrissae from a fourth, and the tactual processes through the feet and nose from still another group He then had each of these groups and also a normal group learn the same maze, and compared the performance of each of the experimental groups with that of the normal. According to Watson, the elimination of any one of these various sense modalities did not disturb the learning process These negative results with exteroceptive stimuli led him to look elsewhere for an explanation of the learning process. Kinaesthesis seemed to be the only remaining possibility. Thus he was led to believe

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that the rat makes the correct turns in the maze on the basis of kinaesthesis—the kinaesthetic sensations coupled with the organic sensations probably, and with the static possibly. For him the maze habit was a chain of kinaesthetically released movements

Carr and Watson (5) placed normal rats into various positions along the true path of a maze which the animals had already learned. The rats were quite disturbed at first, but presently recovered and proceeded along the true path as usual. These experimenters believed that the orientation behavior provided kinaesthetic stimulation for the release of the automatic movements which had previously been acquired. As it appeared to them, the act of running the maze was a series of reflex movements released from kinaesthetic cues derived from running the lengths and making the turns of the true units of the maze. These workers also used a sectionized maze which enabled them to lengthen or shorten certain alleys without altering the general pattern of the maze. Animals which had previously learned the maze were pronouncedly disturbed by changes in the lengths of alleys. The disturbances were attributed to interference with previously developed kinaesthesis. To Carr and Watson the animals resembled machines, carrying out a chain of reflex movements regardless of surroundings.

With the foregoing experimental data as a basis, Carr and Watson offered the thesis that the rat, in learning the maze, merely conditions its responses to the proprioceptive cues afforded by the running itself. This point of view has become firmly intrenched in all discussions of the problem of maze learning. It has extended into more general lines of theoretical reasoning. Reflex-like concepts, such as are implied by the doctrine of kinaethesis, have been advanced as the explanation of all forms of learning Not far remote are the teachings of Thorndike, with their implied specificity of the S-R bond. The doctrine, moreover, has greatly influenced educational theory and practice. It was used for a decade or more to bolster up the old maxim "We learn to do by doing." It thus helped to confirm, to continue, and, in some cases, to extend the practice of emphasizing drill According to the doctrine, a skill is perfected by merely "going through" a certain exercise a sufficient number of times. Thus drill has continued to be a watchword. Only recently has educational practice begun to emerge from the influence of the doctrine of kinaesthesis, despite the accumulation of a somewhat formidable array of experimental evidence which argues strongly against its efficacy as a satisfactory explanation of the learning process.

Watson realized the limitations of his data, and conceded that further experimentation dealing with the positive effect of exteroceptive stimulation might necessitate the formulation of different conclusions. Hunter (17) has since pointed out that Watson did not eliminate every avenue of stimulation other than kinaesthetic; and that when one avenue of stimulation was removed, the animal may have fallen back upon another that was not previously essential Watson (31) himself reports that the performance of his animals was disturbed by rotation of the maze. This observation might well have given him food for thought, for it suggests that exteroceptive cues in the extra-maze environment may have been effective in controlling the habit Watson, however, did not consider this possibility, and explained the phenomenon as being attributable to some sense of direction or static sense. Carr's own later work seems to show the influence of factors other than proprioceptive upon the establishment and control of the maze habit. An experiment in which he used blind and anosmic animals (4) indicates a strong influence of vision and a minimal influence of olfaction upon maze performance. He also determined the effect of rotation and of various changes in the extra-maze environment upon the performance of rats which had previously learned the maze (2, 3, 4). Rotation of the maze 45° disturbed all of the animals, and each of several extra-maze changes disturbed a large proportion of them Carr, however, did not feel that his work had undermined the kinaesthesis hypothesis He still upheld the view that the maze habit consists essentially of a tactual-kinaesthetic motor coordination, although dependent upon a wider sensory situation of which it is a part.

The purpose of this paper is to present briefly a number of studies which indicate that exteroceptive stimuli play a considerable rôle in the establishment and control of the maze habit; and to set forth a number of other studies which argue against the adequacy of proprioception as an explanation of maze learning.

EXTEROCEPTIVE STIMULI

A number of experimental studies on the rat indicate that the maze habit is to a great extent dependent upon exteroceptive stimuli. An experiment by Dennis and Porter (11) leads us at once to question Watson's assumption that the continuance of a response after the deprivation of a stimulus or receptor proves that the deprived stimulus or receptor has been ineffective They tested the possibility of transfer from one sense modality to another. Their rats learned a simple discrimination problem with the opportunity of using three different sensory cues in combination. The maze was a circular plane six feet in diameter The rats emerged through a door from a circular enclosure at the center of the maze, facing the food box which was located just over the edge of the circumference The three cues employed were a strip of metal along the floor leading from the door of the enclosure to the food, a piece of white cardboard above the food, and a buzzer near the food. These stimuli and the food box were constantly rotated to prevent extraneous exteroceptive cues from influencing the response. The animals soon learned the problem. The cues were then eliminated one at a time The animals did as well without the buzzer as with it With the visual cue alone, the animals responded correctly in 89 per cent of the trials, and with the tactual cue alone, in 52 per cent. With special training on the tactual cue alone an accuracy of 93 per cent was obtained. Incidentally the experiment shows the influence of vision and audition upon the control of the maze habit.

An experiment by Dennis (10) seems to explain the behavior of the rats used in the sectionized maze by Carr and Watson. His experiment shows that the rat does not adjust itself to changed conditions in the path which lies before it unless it has been specifically trained to do so. He had eight rats learn an elevated maze constructed of parallel and diagonal blocks set on edge. When he reversed the direction of the first two diagonals, the animals attempted to follow the old pathway. However, with continual change, visual control of the habit soon developed; and this visual control continued to function when an entirely new maze pattern was used The experiment shows that the rat may use visual processes in the development of the maze habit if the situation is such as to make the use of these processes advantageous in adjustment to the problem Similarly Patrick and Anderson (21) have shown that rotation, or variation of stimuli greatly disturbs the behavior of animals trained under constant conditions, but not that of animals trained under systematically varied incidental stimuli.

Dennis' work (8) with blind vibrissaeless and seeing vibrissaeless rats shows that visual and tactual stimuli may be used at least to supplement proprioception. He used a rectangular maze with partitions extending almost across its width The animals, in order to reach the food, were compelled to follow an indirect path around the ends of the partitions. Both the blind and the seeing group soon learned to do this with a fair degree of accuracy. The seeing group made fewer wall contacts than did the blind group When the partitions were removed both groups immediately began to cut across the places where the walls had been and thus achieved a more direct path One may appropriately question whether such behavior is consonant with the kinaesthetic hypothesis. Vincent (28) found that normal rats, in learning a maze, profited by a black trail in the true path and a white trail in the false path, and *vice versa*

Bogardus and Henke (1) have shown that the *development* of the maze habit is closely related to tactual processes They found a high positive correlation between the number of contacts and the number of errors Vincent (29) has shown, by training a group of rats in an elevated maze provided with removable walls and then removing the walls, that tactual processes may be related to maze learning Upon removal of the walls the animals reacted as to a new problem In another experiment with an elevated maze, Vincent (27) found that vibrissaeless rats made more errors and learned with less speed and coordination than did normal rats. When the vibrissae were removed from one side the animal used the other side. However, Vincent still believed that in a *fully formed* habit kinaesthesis predominates

Shepard (24) has shown that the different units of a standard unit maze stimulate differentially The differential cues seemed to be auditory in character, and to come from the floor.

Watson's work (31) on rotation led him to assume that the rat is able to sense direction. It is well known that the rat is especially adept at orienting itself in practically all types of spatial complexes. Dashiell (6) used an open type maze with many alternative equal-length pathways. In this maze he found that learning consisted in establishing not a definite pattern of specific turns, but of some more general orientation function A question arises as to whether such behavior is mediated through the ordinary avenues of stimulation, or whether, as Watson assumed, the rat is equipped with a special sense of direction. Experimental results throw some light on this problem Gengerelli (13) trained rats in a cross maze which was rotated 90° one day and 180° the next, and so on No disturbance resulted from rotation However, when the animals were started in the *food box* they tried to turn in the accustomed manner and thus encountered a door which served to close off one of the unused prongs of the maze. The animals were oriented in a particular way in relation to the starting place, but not in relation to absolute direction. Higginson (14) has shown that in a homogeneous environment rotation does not result in disturbance Trueblood (26) trained 25 rats in a tunnel maze. The maze was then rotated without disturbance in the performance of the animals. The results of these experiments force us to conclude that the rat is not equipped with a special mechanism for detecting direction, and that the orientation function is dependent either upon the various ordinary sensory cues of the moment, or upon some symbolic neural process, or both.

PROPRIOCEPTIVE STIMULI

The experimental studies on proprioception indicate that this process operates within somewhat narrow limits in the establishment and control of the maze habit. Walton (30) established a multiple visual-discrimination response in a six-unit maze, and then attempted to discover whether visual control could be transferred to kinaesthetic. Twenty trials were required for learning He allowed the visual cues to remain in their original positions for 20 trials after the discrimination problem was learned, and then reversed these cues. The animals followed the visual cues A transfer was not effected in 20 trials. Dashiell and Helms (7), using a revolving cross maze with the correct alley inclined at an angle of 30°, were unable to establish a maze habit within the limits of 200 trials. This result is somewhat surprising since Ruch (23) has shown that practically all rats can discriminate an angle as small as 4° Nevertheless, the experiment raises a further question regarding the importance of kinaesthesis as a factor in the establishment of the maze habit.

Dennis (9) attempted to discover whether or not a somewhat simple problem could be solved on the basis of proprioception alone. Differential exteroceptive cues were eliminated. The rats were required to locate a wire ladder in the center of an open space, to climb it, and to run along an elevated surface to food. After the animals learned the problem in daylight, they were tried out in darkness They were unable to solve the problem. Blind rats used on the problem reached an accuracy of only 7 per cent In a modification of this experiment seeing rats learned to run straight ahead to food; but blind rats were unable to do so, making an average error of 15.2°. The experiment shows that without differential exteroceptive stimuli the rat cannot, except by chance, run to a spot a fixed distance ahead. The latter ability should be present if proprioception is to be accepted as the basis of maze learning

Lashley and Ball (19) attacked the problem from a different angle They permitted rats to learn a simple alternation eight-cul maze, then sectioned the proprioceptive tracts of the spinal cord. The ability of their animals to traverse the maze was unimpaired. On the basis of their results these workers rejected the reflex theory and concluded that the motor sequences were determined on the basis of some wholly central neural mechanism

Following a slightly different lead, Dorcas and Gray (12) interfered with kinaesthetic stimulation by removing muscles, limbs, and other parts of the animals They were attempting to discover whether interference with the kinaesthetic pattern of response during learning would disturb the accuracy of performance. There was no significant increase of errors after the operations

AN EXPERIMENT WITH THE TEMPORAL MAZE

Hunter's work (15) on the problem is unique He used a temporal maze A temporal maze (Figure 1) is one in which the animal is required to repeat the various parts of the maze pathway a number of times in new combinations. His was a double alternation prob-

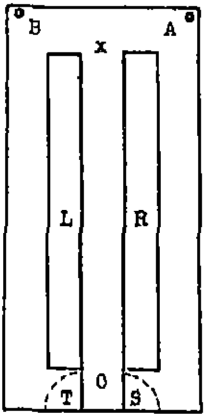

FIGURE 1

A TEMPORAL WATER MAZE

In the double alternation problem (rrll) the animal is required to traverse the following course: Starting from *O*, the first round is made by proceeding down the central alley to point *x*, then turning right around the end of rectangle *R*, and returning by way of door *S* (which is opened at the appropriate moment) to *O*. The second round is a repetition of the first. The third and fourth rounds are similar to the first and second, the difference being that the animal turns left at *x* instead of right, and therefore returns to *O* by way of door *T* instead of door *S*. Either of the two bulbs *A* and *B* may serve as a differential stimulus.

lem requiring the animal (starting at *O*, Figure 1) to run down the central alley and to encircle the rectangle *R* twice, and to follow this by two trips around the rectangle *L*. The doors *S* and *T* were opened at the appropriate moments. In his first experiment Hunter's animals did not solve the problem, even after being trained to the point of mastery in a spatial maze possessing like turns, and then being transferred to the temporal maze. According to the kinaesthetic doctrine, any problem so simple should have been easily solved by all of the animals; for, according to this doctrine, the kinaesthetic cues from running one segment control the running of the next, so that a chain of proprioceptive activity results.

Hunter (16) later trained 11 rats on a double alternation problem on a spatial maze until 10 of them mastered it. This required from 10 to 115 trials. Four of these animals, after being blinded, continued to make perfect records. These four were transferred to an elevated temporal maze and given from 109 to 180 trials, but only three of them ever made the required llrr response. Altogether the animals made only 13 correct responses Thus Hunter found that it was next to impossible to set up a merely temporal sequence of kinaesthetic processes. Why was the problem so difficult? According to the kinaesthetic chain-reflex theory used as an explanation of learning in a spatial maze, the problem should have been easily solved.

The results obtained in the above-mentioned experiment led Hunter to suspect that training under somewhat different conditions might lead to the establishment of the double alternation response in the temporal maze. Hunter, therefore, working with Nagge (18), trained rats in four boxes arranged side by side, the animals being required to turn *left* in the first and second boxes, and *right* in the third and fourth. Three of the boxes were then eliminated, one at a time, to produce a temporal maze Some of the animals ran three or more successive llrr responses when the boxes were reduced to one Thus, with long continued training of a very special kind, Hunter finally succeeded in establishing the double alternation response in a temporal maze But why again was such special training necessary, and why were so many trials required? If the chain reflex is responsible for maze learning why does it fail to operate or operate only in such an unsuccessful manner in the temporal maze? Hunter's work with the temporal maze raised the very pertinent and as yet unanswered question as to how an animal can use the kinaesthesis, connected, let us say, with a right hand turn, at one moment to initiate a turn to the right and at another moment to initiate a turn to the left It is a platitude to say that a stimulus cannot in itself produce first one response and then another. The explanation of the fact that it is almost if not entirely impossible to establish the double alternation response in the temporal maze appears to be this: the use of the temporal maze nullifies the differential value of the *exteroceptive* stimuli. The rat readily learns the *spatial* maze, even though it be extremely complex, because each turn has its own differential *exteroceptive* stimulus cues. After the habit is well established, if the differential exteroceptive cues be gradually withdrawn (thus forming a temporal maze), some of the animals, as Hunter and Nagge have shown, can maintain the response. During the learning process some implicit formulation of the problem is probably effected, and this process now controls the integrated sequence of movements in the absence of differential sensory stimuli.

The writer has recently completed a discrimination experiment which bears on the problem of the rôle of kinaesthesis in the establishment of the maze habit. Six rats were used on a double alternation problem in a temporal water maze (Figure 1) provided with a visual cue. Two ten-watt incandescent light bulbs were hung inside the maze just above the water level, one in each of the two corners, *A* and *B*. The animal started in the maze at *O*, and the problem required that it swim around rectangle *R* twice, and then encircle rectangle *L* twice, thus completing an rrll response before arriving at the goal. The goal consisted of a ladder lowered into compartment *O* just as the animal completed its last round. Bulb *A* served as the differential stimulus: it was kept lighted until the first two rounds were completed. Neither of the bulbs was lighted while the last two rounds were being made

The maze (Figure 1) consisted of a heavy galvanized iron tank (24 inches by 48 inches) in which two galvanized iron boxes, *R* and *L*, were placed as indicated. Two doors were hinged to the end wall of the tank as shown in the figure. The maze was supported by a metal frame 36 inches high. The water in the maze was maintained at a depth of approximately 5 inches. The maze was located in a "dark room" at the middle of the floor, and was illuminated from the center of the ceiling by a 150-watt light provided with an opaque globe. The maze was separated from the experimenter by a heavy black canvas screen 6 feet by 8 feet.

The experimenter started each trial by reaching through a flap in the maze and placing the rat in compartment *O*. Through an "eye hole" in the screen he observed its performance; and by means of handles which projected through the screen, he operated the doors to comply with the conditions of the problem. Each rat was given two trials daily, one in the morning and one in the afternoon.

It will be observed that the animal always arrived at the goal from the left side of the maze. This approach to the goal from the left is mentioned because, after a few trials were completed, it resulted in a definite and strong preference by the animal for the left side of the maze. This preference for the left side of the maze was characterized by persistent left hand turns when the animal arrived at point *x* after traversing the central alley of the maze After a few days' acquaintance with the situation each animal, upon being placed in the maze at *O*, came to take the following path, or some rather close approximation thereto In completing the first round, it swam down the central alley to *x*, turned left and continued on to the closed door *T*; it then retraced its path back to *x* and came on around the right side of the maze and passed through door *S* to the starting point *O*. The second round was a repetition of the first. The third round was a repetition of the first part of the preceding round, but since door *T* was now open, the animal, upon arriving there, passed on into compartment *O* The fourth round was a repetition of the third. Each of the animals persisted in this course for more than 50 trials—some of them as many as 500. Now, since the animal tended to make a left-hand turn on each of the four rounds, it will be seen that the successful solution of the problem required the elimination of the first and second of these left turns. In other words, it required the elimination of the *xTx* loops. Five of the six animals succeeded in eliminating these loops in from 90 to 500 trials, and thus arrived at a solution of the problem The loops were eliminated one at a time.

The series of trials in which a right turn at *x* was in the process of being substituted for a left turn, on the first and on the second round of each trial, was most interesting to observe Each animal reached a point in its training where, upon arriving at *x*, it appeared to be held on a balance, and would shift from side to side in the central alley, turning and extending the head in the direction of the shift One of the animals, in making the first round on a number of trials, shifted back and forth as many as eight times. At this stage the time required for a trial often doubled or even trebled that required in earlier stages of training. After making such indecisive responses on a considerable number of trials, the animal eventually achieved a right-hand turn on the second round. This was later followed by a right-hand turn on the first as well as on the second round, and thus the problem was completely solved. After a solution of the problem was once achieved, the animals reverted only occasionally to the left-hand turns on the first two rounds.

The question may now be raised as to what rôle kinaesthesis played in the establishment of this double alternation response. Until one of the loops was eliminated, practically all of the turns at x were left-hand turns. From then on until the other loop was eliminated, approximately three-fourths of the turns were to the left. Even after the problem was solved half of the turns were still of the left-hand type. So we have the case of a group of rats, each of which has made hundreds of left turns and almost no right turns, beginning to eliminate the first two left-hand turns Is it possible to explain this modification of behavior on the basis of kinaesthesis? It would appear that if kinaesthesis is a factor in the establishment of the maze habit, these animals learned the maze in spite of it rather than because of it.

The results of this experiment seem to argue strongly against the doctrine of kinaesthesis, and to suggest that the modification in behavior was achieved on the basis of some symbolic neural process, either central or peripheral. This suggestion is strengthened by the fact that three of the animals were able to continue their control of the habit upon removal of the visual cue, and the other two were able to regain it after a few additional trials with the visual cue removed.

AN EXPERIMENT ON ALTERING THE PATTERN OF LOCOMOTION

Macfarlane (20), like Lashley and Ball, and Dorcas and Gray, attempted to discover the effect that a change of kinaesthetic pattern would have upon the establishment and control of the maze habit. He altered the kinaesthetic pattern, however, not by transecting neural pathways nor by removing muscles, etc., but by changing the pattern of movement of the animal from one of swimming to one of running and *vice versa*. He used a 10-cul maze consisting essentially of 10 boxes (5 inches by 35 inches) set side by side. The true path led from the first box through a door into the middle of the second, from the second box through a door into the middle of the third, and so on. Change of movement pattern *during the learning process* scarcely altered the shape of the learning curves for time and errors. This leads one to infer that in the early stages of learning the rats depended primarily upon exteroceptive stimuli. When the change of movement pattern occurred *after mastery of the problem had been achieved*, many of the animals were able to traverse the maze as usual, and the increase in errors for most of the others was small

These facts lead to the inference that the maze habit was controlled by processes other than kinaesthetic.

Macfarlane's method seems peculiarly adaptable to a solution of the problem He has pointed out that the pattern of movement in swimming differs radically from that in running: the former is one of being flattened out, whereas the latter is one of being pulled together, so to speak. It appears unquestionable that the kinaesthetic *patterns* of stimulation in the two types of locomotion are different

Macfarlane's results show that, under his conditions, the kinaesthetic factor is indeed a small one in the establishment and control of the maze habit. However, a study of Macfarlane's maze raises the question as to whether it was so constructed as to favor contributions of a kinaesthetic nature Examination of the maze leads one to suspect that it is especially favorable to visual control for the animal, in order to follow the true path, needs only enter each *compartment through a door on one side, and emerge from the* compartment through a door on the opposite side From the place of entry of the animal in each compartment the exit door on the opposite side of the compartment is always conspicuously located at a distance not greater than 16 inches Robinson and Wever (22) have shown that white rats are able to ascertain visually whether a path is open or closed at a distance of 18 inches It may be that the problem resolved itself into one of entering each compartment in succession at one side, seeing the exit on the opposite side, and following that exit.

The writer desired to ascertain whether results similar to those obtained by Macfarlane would accrue in a maze so constructed as to obviate the easy visual cues. The problem was limited to one of determining the effect of a change of movement pattern (swimming to running) upon the *control* of an established maze habit.

The maze used is illustrated in Figure 2 It is an 8-cul multiple-*T maze with walls and floor constructed of sections of galvanized* iron The walls are 12 inches high and the maze pathways are 5½ inches wide. Compartment 1 is the starting box and *G* is the goal (a bakelite stand supported by metal legs 5½ inches high) The maze is situated in a glass box 50 inches square by 14 inches deep. This box, including the maze, was enclosed in a beaver-board box the ceiling of which was 48 inches above the floor of the maze. The maze was lighted internally by nine 25-watt bulbs arranged

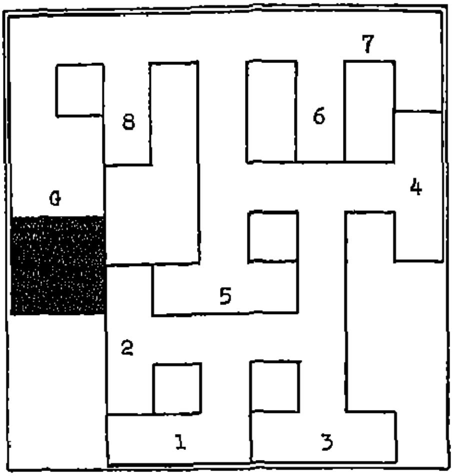

FIGURE 2

A SPATIAL MAZE FOR DETERMINING THE EFFECT OF AN ALTERED PATTERN OF LOCOMOTION UPON THE CONTROL OF A MAZE HABIT

The maze is constructed of sections of galvanized iron, and is located in a glass box which contains water at a depth of five inches Compartment 1 is the starting box, and the black square G is the goal Compartments 1, 2, 3, 4, 5, 6, 7, and 8, are the culs-de-sac.

at regular intervals in the ceiling of the box enclosure. This box was provided with three doors, each 12 inches square, one located in the front wall and one on either side. The water in the glass box and maze was maintained at a depth of approximately 5 inches. The experiment was conducted during the months of July and August, and no attempt was made to control the temperature of the water. Presumably it did not differ greatly from that of the atmosphere. The reliability of the maze was computed by correlating the errors of the odd-numbered runs with the errors of the even-numbered runs. The first 26 trials were used in the computation. the coefficient was found to be .9.

Thirty-four white rats were used in the experiment. Males and females were equally represented The animals were 40 days old at the beginning of the experiment.

Establishing the Habit: A Swimming Pattern A trial was given by introducing the rat into compartment 1 (Figure 2) of the maze by way of the front door of the maze enclosure. The animal was placed with the head toward the blind end of the compartment so that the hand could be removed and the door of the box closed before the animal was started on its way in the maze. When the rat arrived at the goal (*G*), it was removed from the maze by way of one of the side doors of the maze enclosure, and immediately returned to its living cage. Each animal was given one trial daily for 45 days.

In scoring for errors, the animal was considered to have entered a cul when its head and shoulders were carried into the alley leading thereto. Retracing errors as well as errors made in a forward moving direction were counted A record of the time occupied by each trial was kept. The time of a trial was taken as the time spent in the water Figure 3 shows the average number of errors made, the average time consumed, and the number of animals that made errorless runs, on each of the 45 trials. A glance at the curves for time and errors shows that the maze habit was rather well established before the tenth trial. However, the training was continued for 35 more trials, if possible, for the purpose of establishing a kinaesthetic pattern of control

This training period was marked by only two events of unusual interest. The first was an electric storm which occurred during the 18th trial Thunder and lightning were almost incessant throughout this trial period. A large tree near the building was shattered by lightning. On this trial there was a great increase in average time, and a slight increase in the average number of errors. The other event, which occurred at the 22nd trial, was an unusually hot day—mercury at 103 F. The rats seemed almost overcome, and, upon being placed in the water, would float for a considerable length of time before starting to swim down the maze pathway. The average time was greatly increased. The errors, however, did not increase appreciably.

Alteration of the Pattern: A Running Pattern. On the 46th trial the pattern of movement was changed from one of swimming to one of running. This was accomplished by introducing a false floor into the maze alleys. The floor consisted of wire cloth attached to the walls of the maze with its surface in a horizontal position one inch beneath the surface of the water. In conducting a trial the animal

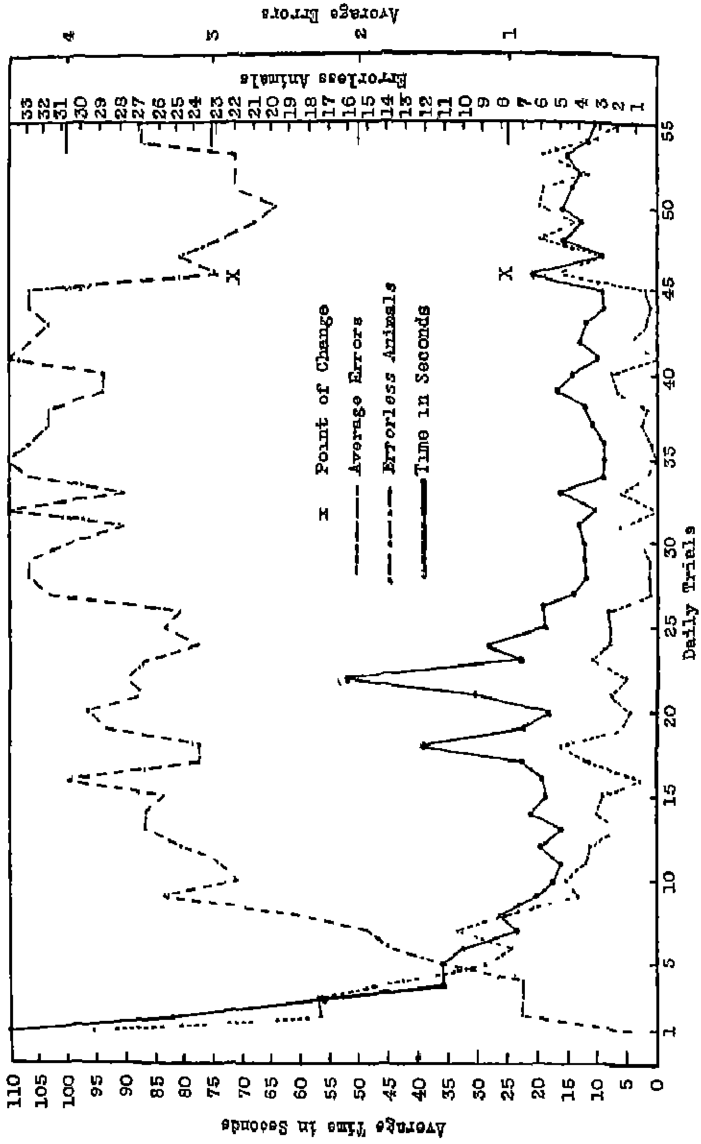

FIGURE 3

THE EFFECT OF A CHANGE OF MOVEMENT PATTERN—SWIMMING TO RUNNING—UPON THE CONTROL OF A MAZE HABIT was introduced into the maze as usual, but on account of the false floor it was compelled to wade in water one inch deep rather than to swim as in the foregoing trials. With the arrangement of the maze the animals were given ten trials each The results as regards errors, time, and errorless animals are given in Figure 3. There was a considerable increase in both the average time and the average number of errors A comparison of the errors made on trials 45 and 46 may be had by a glance at Table 1

TABLE 1

COMPARISON OF ERRORS ON TRIALS 45 AND 46

Mean errors on trial 45	058	σ	.0578
Mean errors on trial 46	.676	σ	.198
Difference	618	σ	.2062
Difference /σ difference	2 99		
Odds favoring a difference	99 9 to 1		

A comparison of the time consumed in trials 45 and 46 may be had from Table 2

TABLE 2

COMPARISON OF TIME ON TRIALS 45 AND 46

Mean time on trial 45	9 55″	σ	1.03″
Mean time on trial 46	21 41″	σ	4 8 ″
Difference	11 86″	σ	4 9 ″
Difference /σ difference	2.42		
Odds favoring a difference	99.2 to 8		

The foregoing tables show that the differences statistically are real differences. However, the 46th trial did not bring about a reversion to initial performance. The average of the errors on the 46th trial was .676, whereas the average of the errors on trial 1 was 3 823. The average time on the 46th trial was 21 41 seconds, whereas the average time on trial 1 was 110 seconds. Moreover, this increase in time and errors accompanying the change of movement pattern was not a characteristic of the behavior of all of the animals. Reference to Figure 3 shows that 23 of the animals remained errorless on the 46th trial In other words, so far as errors were concerned, over half of the animals remained undisturbed by a change of movement pattern from one of swimming to one of running. Table 3 gives the number of errorless animals, the number of animals making errors, the total number of errors made, and the aver-

TABLE 3

Trial number	46	47	48	49	50	51	52	53	54	55
Errorless animals	23	25	23	21	20	22	22	22	27	27
Erring animals	11	9	11	13	14	12	12	12	7	7
Total errors	23	13	27	19	27	26	16	26	14	9
Average number errors per erring animal	2.09	1.44	2.45	1.46	1.92	2.16	1.33	2.16	2.00	1.28

age number of errors of the erring animals, on each of the ten trials, made subsequent to the introduction of the change in movement pattern. More than half of the animals were errorless in each of the ten trials attended by the altered pattern. Furthermore, the increase in errors and time which occurred with some of the animals need not be attributed to disturbance of a kinaesthetic chain reflex: subsequent to the 45th trial, the exteroceptive pattern of stimulation must have been somewhat modified by a change in tactile stimulation of the feet, and probably by a change in visual stimulation resulting from an altered head carriage

The results of this experiment with the *T* maze agree essentially with those obtained by Macfarlane with his rectangular box maze, and strengthen the evidence for the contention that the maze habit is controlled on the basis of some process or processes other than kinaesthetic

CONCLUSIONS

In the light of the studies given in this paper it appears that the doctrine of kinaesthesis is inadequate as an explanation of the establishment and control of the maze habit. The studies on proprioception indicate that:

1. The rat encounters the greatest difficulty in adjusting adequately to the maze on the basis of kinaesthesis alone
2. The rat often succeeds in the establishment of the habit in spite of kinaesthesis.
3. Interference with the kinaesthetic pattern of stimulation may not disturb the course of the learning process.
4. Interference with the kinaesthetic pattern of stimulation may not disturb the control of a fully formed habit.

Practically all the studies mentioned in this paper indicate that exteroceptive stimuli play a large rôle in maze learning. When the various features of the stimulating situation are altered indiscriminately, disturbance in performance results. However, when certain features are kept constant, even though all others are changed, the animal may remain undisturbed

Just *how* the extereoceptive stimuli function in the development and control of the habit is not so clear It may be that the stimuli usually function only momentarily to direct the animal into the immediately new stimulating situation, where the process is again repeated, and so on throughout the course of the maze. This much seems certain: whenever the maze is so constructed that each part possesses its own differential exteroceptive stimulus cues (a spatial maze), the rat readily adjusts itself to it, even though it be very complex. On the other hand, when the maze is so constructed as to nullify the differential stimulating values of certain parts (a temporal maze), equivocal responses develop, and the animal encounters great difficulty in making the proper adjustment Nevertheless, by training of a very special type, it is possible for the rat to develop a maze habit which can be controlled in the absence of differential exteroceptive stimuli. It is evident that such responses must involve elements of a highly symbolic and delayed character. This is a way of saying that the responses involve elements which are indicative of conditions in the maze far in advance of the animal. And who can say but that all maze learning involves elements of a symbolic character? It may be that the rat eliminates the culs of the spatial maze by a process similar in kind, only less elaborate. This is not the problem of the present study however; it is only an interesting question raised by an investigation of the rôle played by kinaesthesis in the establishment and control of the maze habit.

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LE RÔLE DE LA KINESTHÉSIE DANS L'ÉTABLISSEMENT ET LE CONTRÔLE DE L'HABITUDE LABYRINTHIQUE

(Résumé)

On résume brièvement nombre d'expériences sur les effets des stimuli extéroceptifs sur l'apprentissage du labyrinthe par les rats. Les résultats de ces expériences indiquent que les stimuli extéroceptifs jouent un rôle considérable

On présente aussi nombre d'expériences sur les effets des stimuli proprioceptifs sur l'établissement et le contrôle de l'habitude labyrinthique Deux expériences de ce groupe-ci ont été faites par l'auteur. Dans la première expérience on a employé six rats sur un problème de discrimination à alternation double dans un labyrinthe temporel à eau Cinq d'entre les animaux ont appris le problème (c'est-à-dire, ont appris à tourner à droite dans les deux premiers parcours) en de 50 à 500 épreuves, malgré l'exercice persistant et continu pendant longtemps de tourner à gauche

Dans la seconde expérience on a employé trente-quatre rats dans un labyrinthe spatial à eau en forme de T composé de 8 culs pour tester l'effet d'une forme de changement de mouvement (l'action de courir au lieu de nager) sur le contrôle d'une habitude labyrinthique établie Vingt-trois des animaux n'ont pas été dérangés par le changement de la forme

Les résultats de ces expériences sur la proprioception s'opposent à la kinesthésie comme explication adéquate de l'apprentissage du labyrinthe

S. Evans

DIE ROLLE DER KINASTHESIE BEI DER FESTSETZUNG UND KONTROLLE DER LABYRINTHGEWOHNHEIT

(Referat)

Eine Anzahl der Experimente uber die Wirkungen der exterozeptiven Reize auf das Labyrinthlernen bei Ratten werden kurz besprochen Die Ergebnisse dieser Experimente weisen darauf hin, dass exterozeptive Reize eine wichtige Rolle spielen

Eine Anzahl Experimente uber die Wirkungen der propriozeptiven Reize auf die Festsetzung und Kontrolle der Labyrinthgewohnheit werden angegeben Zwei Experimente der letzteren Gruppe wurden von dem Autor ausgefuhrt In dem ersten Versuch wurden sechs Ratten bei einem Doppelabwechselungsunterscheidungsproblem in einem Zeitwasserlabyrinth gebraucht Funf der Tiere lernten das Problem (d h. lernten das Rechts-

biegen bei der zweiten Runde) in von 50 bis 500 Proben, trotz der beharrlichen und langen Übung beim Linksbiegen

In dem zweiten Experiment wurden vierunddreissig Ratten in einem achtgangigen Raum-T-Wasserlabyrinth gebraucht, um die Wirkung einer Veranderung des Bewegungsmusters (Schwimmen oder Gehen) auf die Kontrolle einer festgesetzten Labyrinthgewohnheit zu erforschen Dreiundzwanzig der Tiere blieben durch die Veranderung des Musters unverwirrt

Die Ergebnisse dieser Versuche uber Propriozeption sprechen gegen die Angemessenheit der Kinasthesie als Erklarung des Labyrinthlernens.

S. EVANS

THE DEVELOPMENT OF CONCEPTS*

(*A Study of Children's Drawings*)

From the Harriette Melissa Mills Training School

SINA M MOTT

INTRODUCTION

A student in the study of child life investigates the process of concept formation that he may more intelligently participate in the directing of personality development. At the outset, therefore, he acquaints himself with the studies concerning the development of concepts which have accumulated through the centuries Having these he weighs and considers them in the light of scientific findings in order to discover a foundation on which he may base a program. With these findings in mind he is then at liberty to project his advanced study or lay a program for careful investigation of unsolved problems

THE PURPOSE OF THE STUDY

It is the purpose of this study (1) to present a brief outline of the major studies in the development of concepts and of children's drawings and (2) to give a summary of an investigation concerning the relationship between the formation of concepts and the child's overt behavior

HISTORICAL SURVEY

From a survey of the studies in the development of concepts it may be seen that·

1. By theory or by assumption it has been held that
   - *a* Thinking progresses·
     - 1) From the whole to the part—Deductive (49)
     - 2) From the part to the whole—Inductive (2, 16, 17)
   - *b* All concepts are built
     - 1) From the perceptions which come through the channel of the senses (20, 40, 69).

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  2) From the *material which comes to the individual* either by way of the senses or by reasoning (69, pp. 82-83).
- c Perceptions are welded together to form concepts by various forms of association (3, 28, 30, 31, 46-48, 66, 67, 71)
- d Concepts are built by means of "brain paths" or S-R bonds (29, 64) In opposition to this see (21, 36, 37, 70).

2 By research and experimentation it has been found that.

- a *Development* progresses from the whole to the part
  - 1) Body movements progress from the organism-as-a-whole to differentiated and specialized activities (15, 18, 26).
  - 2) Learning progresses from the vague impression of the undifferentiated total to the emergence of discrete elements (1, 19, 55).
- b Maturation is not caused by experience but it progresses with it (8, 9, 12, 13, 15, pp. 989-1009)
- c Certain chemical compounds may deter physical activity without hindering maturation (15, pp 989-1009)
- d A discrete element of a total pattern may under favorable conditions call forth the response which had previously been given to the total pattern (35, 52, 53, 56).[1]

As the findings presented in part 2 have been discovered by scientific research and have been found true by experimentation and testing, they are held in mind for future use. Now in order to determine some of the factors which influence the formation of concepts it would be wise to study those made by very young children. But here one is handicapped by the meagerness of the child's vocabulary Inasmuch as the child is able to portray by means of drawings concepts which he is not yet able to express by either written or spoken language, the investigator turns to this form of expression as a means of determining the child's concepts.

A survey of the studies made in children's drawings show that they have followed roughly nine different lines. These are presented briefly in Table 1. From these studies it may be seen that· (1) drawing is a form of expression, (2) the child up to the age of nine years draws from memory—he thus portrays his mental pictures;

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[1] For a fuller discussion concerning these studies see Mott, S M., The Development of Concepts (A Study of Children's Drawings) Ph.D Thesis New York Univ, 1935. Pp 2-20.

TABLE 1

STUDIES MADE IN CHILDREN'S DRAWINGS

Worker	Field	Significant contribution
Preyer	Individual	Pioneer work in the field.
Stern	"	Notes on the development of son's drawings
Luquet	"	"Conservation and modification of type"
Eng	"	Comparative study of Margaret's drawings with those of other children of same age and of these drawings with those of primitive peoples
Lamprecht	Race	Study of racial similarity and differences
Levinstein		
Ricci	Knowledge	Drawing describes an object according as the memory of it is more or less clear in the child's mind
Passy	"	Drawings are a collection of impressions more or less separate, each being drawn without regard for its relationship to another
Barnes	"	Drawing is for the child a language, he thinks in small units
Lukens	"	Comparative study of drawing and language
Sully	"	Study of stages in the drawing of the hand
Childs	Drawing ability	Scale for measurement of drawing ability
Kline-Carey	"	Scale for measurement of drawing ability.
McCarty	"	Scale for measurement of drawing ability.
Thorndike	"	Scale for measurement of drawing ability
Karrenberg	Effect of drawing lessons on drawing	A child's drawing may be improved without altering his individual style
Herrick	Interest	Pioneer work in the field
Katzaroff		
Maitland	"	Interest shift with chronological age
Partridge	"	Comparative study of the frequencies with which children of different ages draw various parts of human figure
Schuyten -	Norms	Pioneer work.
Lobsein	"	Norms based on the proportions of the various parts of the human figure
Ivanoff	"	Six-point scale
Kerschensteiner		The ten steps in the development of drawing of the human figure

TABLE 1 (*continued*)

Goodenough	"	Scale for the measurement of intelligence by drawing
Ballard	Sex differences	Drawings of boys differ from those of girls in the choice of parts emphasized
Burt	Nervous disorders	There is a qualitative and quantitative difference between the drawings of normal and subnormal children
Prizhorn	"	Drawings of patients in hospitals for mental disorders differ in content and quality from those of normal people.
Pearson	"	Restlessness and emotional infantilism are portrayed in the composition of the drawings of deficient children *

* For a fuller discussion of these studies see Mott, S M, The development of concepts (a study of children's drawings), Ph.D Thesis, New York Univ, 1935 Pp 21-37

(3) the child, up to the age of nine years, draws the human figure in preference to other objects; (4) there exists a close relationship between concept development and general intelligence; (5) and drawings made by children with mental diseases differ in content and quality from those drawn by normal children.

After noting the general development of the "schema" from the viewpoint of the addition of the various parts of the figure (22, 23, 33, 42), the child psychologist may well turn his attention to individual differences. Each child builds his own "schema" according to his own design. One builds his out of many short lines, another scarcely lifts his pencil. One has many broken disconnected lines, another a few swinging strokes. One child painstakingly reproduces an intricate design over and over again, another dashes off his with speed and ease. Not only do these mechanical elements differ from drawing to drawing but also the time taken to construct the drawing Then, again, while one "man" is merely a head with a few useless appendages dangling in mid-air, another is rushing down the street with his milk bottles, while a third is taking a dog for a walk These are items which a student, interested in child psychology, will note, and of these only two have come to the attention of the research workers Concerning the first, Pearson (54) found that many short and broken lines were indicative of restlessness and emotional infantilism The second—the portrayal of activity—has been alluded to casually by the authors of individual studies (10, 22, 25, 42, 43, 57, 62) Being interested in making a chronological study, they have confined their study to locating the age of the child when he first represented an individual engaged in an activity and the type of activity portrayed One notes the fact that Luquet's Simonne portrays activity two and a half years before Scupin's Bubi In fact there is such a wide range of ages that one wonders if the controlling factor is age

THE METHOD USED IN THIS STUDY CONTRASTED WITH OTHER METHODS

The method used in an investigation is determined by the particular end in view and by the nature of the material to be sought. When one wishes to acquire data on some one point over a wide range of years or peoples then one selects the latitudinal method for study. Thus Kerschensteiner (33), and Goodenough (23), wishing to determine norms, collected hundreds from the various ages. Maitland (44) and Partridge (50), concerned in an extensive study of children's interests at the different age levels, gathered a multitude of drawings throughout the grades. The drawing scales of Thorndike (64) and Kline and Carey (34) necessitated the collecting of children's drawings over a widespread area both in respect to chronological age and drawing ability. Likewise when one determines the differences in content and quality of the drawings made by children of different nationalities, as did Lamprechest and Levinstein (38), one collects hundreds of drawings from the various nations. In each of these cases the drawings of a certain child were held valuable only as they represented those of a hundred other children of the same age or nationality Having once been drawn they were no longer considered in relationship to the child who drew them but in relationship to those drawn by hundreds of other children of the same chronological age, same mental age, or the same nationality. Much can be said for this widespread, short time latitudinal method of investigation Where the material to be discovered and the end in view lends itself to this method, the experimenter is very fortunate

But there are some studies which do not fit into the latitudinal method of investigation. Many psychologists feel that there are points in the mental development of the child which cannot be ascertained by the cross-sectional technique Thus Preyer (57), Shinn (61) and Valentine (68) have used the biographical or longitudinal method of investigation What these workers have done in their fields Luquet (42) and Eng (22) have done in the study of the drawings of individual children. Here the drawings were collected and the necessary data recorded on each drawing from the time the child first began to use the pencil until she was eight or more years of age. The value of this type of study lies in the recondite view of the development. Although they offer but few solutions to problems, they furnish a mine of suggestions for scientific investigations.

The method used in this investigation partook of the nature of the latitudinal in that it was a study of the drawings of 138 children —562 drawings. Not only were the drawings made by these children studied but also the results of. (1) three mental tests, (2) three personality tests, (3) three muscle coordination tests and (4) two drawing tests besides the curve-angle study given to the first 40 children This study had an average of 16 items to study in connection with each child or a total of 1749 factors. Thus a sufficient number of children were used to warrant the use of statistical methods. But this investigation differed from the usual latitudinal method in that the drawings were considered in relationship to the child who drew them The first 101 made three drawings apiece and the last 37 drew seven. On the sheet on which the child made his drawing were recorded the name of the child and the time taken to draw the picture, together with the name of the person and the object drawn. Thus this investigation partook of the nature of the intensive study in that it was interested in the drawings of the individual child in relationship to his personality and it was extensive in that it covered a sufficient number to warrant the use of statistical methods

THE ORDER FOR COLLECTING THE MATERIAL

The material was collected in the order of. (1) call for the picture:

> Today we are going to draw a picture of a person It may be any person that you choose Draw the very best one that you can Take all the time that you wish When you are done raise your hand that we may know that you are through and may take up the paper.

As each completed his drawing, the amount of time required to make the picture and the name of the person drawn were recorded on the sheet This was followed by (2) a group test and then (3) the individual tests. The same procedure was followed on the second day, an alteration being the call for a "man" to be drawn. The third day the call was for a "man and something else."

The Analysis of the Drawings

The analysis of the drawings involved. the study of the lines used in drawing the picture, the curve-angle relationship, the ratio of the

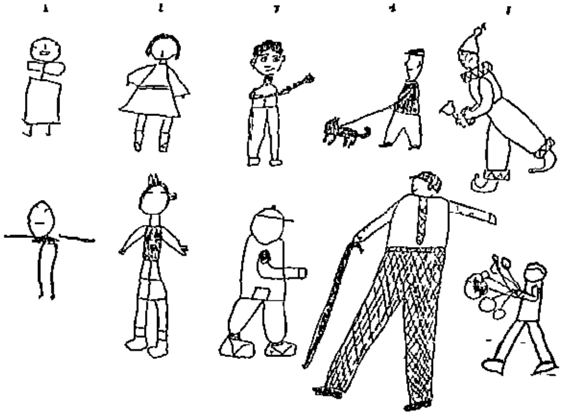

FIGURE 1

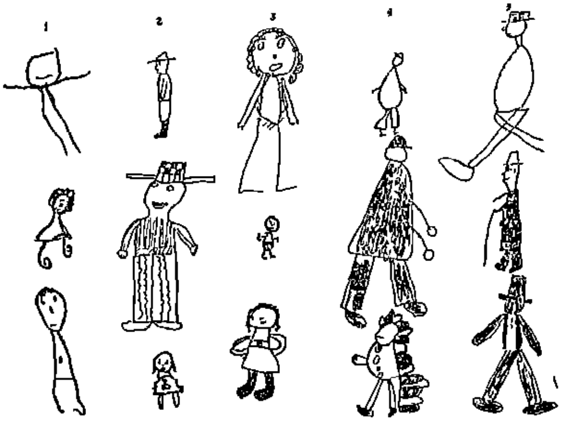

FIGURE 2

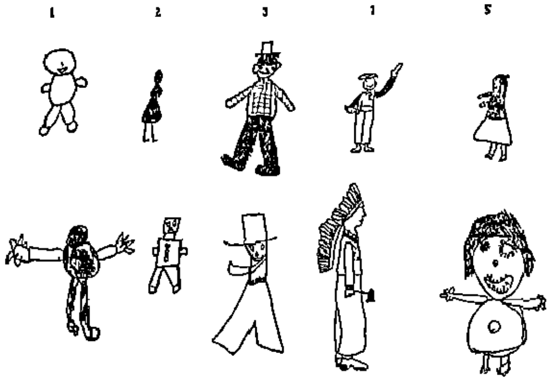

FIGURE 3

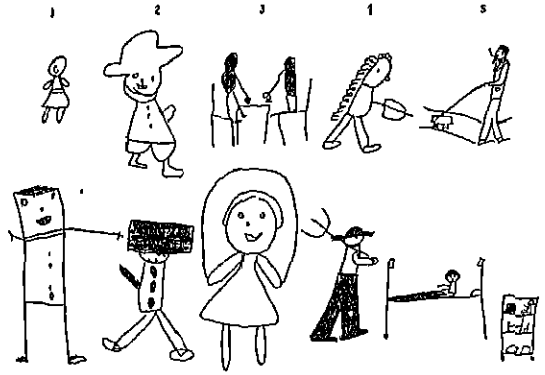

FIGURE 4

length to the width and of the head to the other parts of the body, the insertion of different elements, the time required to make the drawings, the number of different objects added, the activity portrayed, and the portrayal of an awareness of one's environment.

The Scale

The five items: the time taken to draw the picture, ratio of the length to the width, the number of additional objects, the portrayal of activity, and the portrayal of an awareness of one's environment became the basis for the construction of a scale It was found, by trial and error, that the first three items fitted readily into five-point scales.

TIME

1	2	3	4	5
minutes	minutes	minutes	minutes	minutes
— 11	10 8	7 5	4 3	2 —

RATIO OF THE LENGTH TO THE WIDTH

1	2	3	4	5
— ⅔	1 1⅓	1⅔ 2⅓	2⅔ 3⅓	3⅔ —

NUMBER OF ADDITIONAL OBJECTS

1	2	3	4	5
Less than required	Required	One added	Two different	Three or more different

The sorting technique was employed for the last two items. Each of the three sets of drawings were handed to five different graduate students to sort into five piles. (1) activity portrayed in (*A*) arms and (*B*) legs, and (2) awareness of one's environment as to (*C*) dress and (*D*) type of activity The directions given for sorting the pictures for activity in the arms was.

> You are asked to consider only the activity portrayed in the arms. After discarding all the pictures in which there are no arms drawn, sort the remaining ones into five piles—No 1 no activity portrayed No 5 the portrayal of the greatest amount of activity Make as many alterations as you wish until you are satisfied with the position assigned to each drawing

Those pictures in which there was a complete agreement as to the place in the five-point scale were selected as the pattern for that place. Two pictures were then pulled from each of the five places, mounted on a sheet and photostated They thus became the scale for measuring the portrayal of activity as expressed in the arms. The same procedure was followed for the other three factors. The characteristics for each of the five places for the four scales are:

a. *Activity portrayed in the arms*

1 No activity portrayed in the shoulders, elbows or hands
2 Freedom at the shoulders but none at elbow or hand
3 Freedom at both the shoulder and elbow
4 Less freedom but the accompanying object suggests the activity
5 Freedom in the shoulder, and elbow The individual is actually engaged in an activity (p VI)

b Activity portrayed in the legs
  1 Legs appear to be useless Figure could not stand on them
  2 Individual represented as standing, legs parallel
  3 Legs not parallel, feet turned in the same direction, but little idea of walking portrayed
  4 Feet in the same direction, person walking
  5 Greater freedom in hips and knees, the accompanying object shows that the child thinks of the person walking (p VII)

c. Awareness of one's environment—dress
  1 No sign of any dress
  2 Dress suggested by buttons or general outline
  3 Simple dress of a general type
  4 Type costume—Indian, cowboy, policeman
  5 Dress of immediate environment (p VIII)

d. Awareness of one's environment—type of activity
  1 Figure merely standing
  2 Activity of a general type such as walking
  3 Activity less general, yet one which all might perform
  4 Activity engaged in by a certain profession or group
  5 Activity typical of the immediate home environment (p IX)

Thus, inasmuch as these were "knowledge" pictures, it may be said that insofar as this scale measured the number of additional objects, the activity portrayed, the proportion of one part to another, and the awareness of one's environment, it measured, the association (or suggestibility), the concept of proportion, the activity concept, and the awareness of one's environment, which were a part of the child's knowledge. In other words, the scale measured by use of a *mirror—the drawings—these personality traits.*

THE FINDINGS

Upon completing the construction of the scale it was used by five other graduate students in rating the pictures Table 2 contains the coefficients obtained by comparing the scores on the various parts of the scale and also the coefficients obtained by comparing the combined score on the scale with the scores on the other tests and scales. The coefficient of .664 which these scores have with the scores on the Marston Scale is more clearly understood when the

TABLE 2

Coefficients of Correlation

	Element Compared with other factors	r	P E
	Additional objects		
1	Activity expressed in the arms	366	± 065
2	Activity expressed in the legs	563	061
3	Awareness of one's environment—activity	484	064
	Activity expressed in the legs		
1	Activity expressed in the arms	735	033
2	Awareness of one's environment—activity	.624	043
3	Awareness of one's environment—dress	537	050
4	Ratio of length/width	373	062
	Awareness of one's environment		
1	Activity compared with dress	659	039
	Combined score on activity expressed in arms and legs		
1	Time taken to draw the picture	521	049
2	Scores on questions 3 and 13 of Marston Scale	479	052
	Scores on the scale		
1	Chronological age	501	.050
2	IQ (Pintner-Cunningham)	251	063
3	IQ (Goodenough)	244	.063
4	Rogers' Personality Adjustment	— 059	068
5	Thorndike Scale	564	046
6	Scores on the Marston Scale	664	037
	Chronological age		
1	Thorndike Scale	511	050
2	Scores on the Marston Scale	021	.068

scales for the five factors are parallel with the statements on the Marston Scale This coefficient is all the more significant when compared with the coefficient 021 which the scores on the Marston Scale have with the chronological age It would therefore appear that there is a definite relationship between the overt expression of the personality traits (quickness to respond to a situation, participation in activities, association with others and an awareness of one's environment) which are measured by the Marston Scale and those same traits as measured by the scale This means that there is a definite relationship between the personality trait and the overt expression of the same trait

VALIDATING THE FINDINGS

Inasmuch as the drawings were measured by the scale which had been constructed by the use of these same drawings the results thus obtained were checked by investigating a new group of children The only alterations in the procedure were:

1. Every child held his paper 13 minutes, but the time used in drawing the person was recorded on the sheet
2. Four additional pictures were called for a person and something else, an Indian, policeman, and cowboy

Table 3 presents the coefficients which show the relationships existing between the scores on the scale and the scores on the other scales and tests.

TABLE 3

THE SCORES ON THE SCALE COMPARED WITH THE SCORES ON THE OTHER TESTS AND SCALES

	Scales	*r*	P E.
1	Chronological age	486	± 066
2	IQ (Pintner-Cunningham)	.440	066
3	IQ (Goodenough)	542	065
4	Thorndike Scale	.643	065
5	Scores on the Marston Scale	769	.063

THE SIGNIFICANT ASPECTS OF THE STUDY

Perhaps the most significant element in the study is the attempt to investigate the development of concepts in their relation to the personality traits of the child It has often been said that the blacksmith sees the world through a horseshoe, the cobbler through the soles of a boot, and a dispeptic through a sour stomach, but just what relationship existed between the concept formation and the overt behavior of the child had not been definitely studied

The fact that there is a coefficient of correlation of 769 (± 063) between the portrayal of activity, tendency to associate with others, and an awareness of one's environment in the concepts and the overt expression of these same traits would lead one to ask Is the concept the result of the overt behavor, is the overt behavior the expression of the concept, or may they both be the result of something else?

It was noted that the child who portrayed activity in respect to the "man" and the "person" also portrayed activity in respect to the "cowboy," the "Indian," and the "policeman," as well as animals such as dogs, horses, and chickens. Thus it is seen that the general activity pattern was so well established as to act as a controlling factor in the building of new concepts. Using a different figure of speech, it would seem that it acted as a guide light so that the child saw the world, in general, as an active world When this is true for activity and the tendency to associate with others, one wonders about other behavior patterns The fact that these patterns—activity and the tendency to associate with others—are so well established at six years of age and the fact that they influence the acceptance of new ideas makes one realize the importance of helping the child develop socially acceptable behavior patterns.

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SHORT ARTICLES AND NOTES

THE INFLUENCE OF QUANTITATIVE STUNTING ON LEARNING ABILITY IN MICE[1]

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The influence of quantitative stunting on learning ability in the white rat has been investigated by Anderson and Smith (1, 2) and Ruch (3). In general it has been found that stunted rats learn a maze more readily than do rats that are fed a quantitatively adequate diet The present brief study offers a corroborative evidence with mice as subjects

The apparatus used was a six culs-de-sac linear pattern of the Warner-Warden maze, as shown in Figure 1. It was constructed of wood and covered with wire mesh—the entire apparatus being painted a dull black.

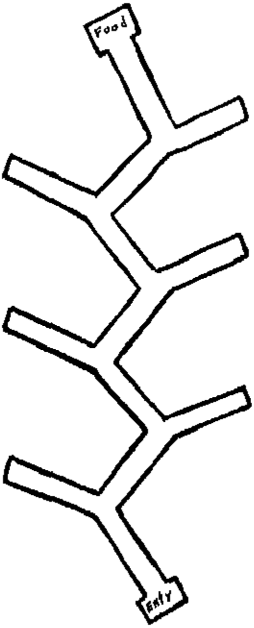

FIGURE 1

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[1] Thanks are due to Dr Alexis Carrel of the Rockefeller Institute for supplying the animals and for making available the research facilities of the Institute for this study

The tests were made in the evening on six nights a week. Each mouse was given two preliminary trials on two successive days in which exploration of the outside of the maze, and feeding for two minutes in the food-box, was allowed. In the training series, two trials per day were given If more than five minutes were consumed in reaching the food-box, the animal was removed from the maze and returned (without feeding) to its cage, and a failure recorded The animals were transferred about by grasping the tail, which did not appear to be disturbing The norm of mastery was three perfect trials out of four The maze was washed with a weak alcohol solution daily Error and time data were taken in the usual manner.

Neither of the two groups was deprived of water during the training or the pre-training period. The animals were 24 hours hungry when tested The diet for the two groups was qualitatively the same and consisted principally of the Sherman standard diet (cracked whole wheat, 2 parts; klim, 1 part, 1% salt; 0 5% sodium carbonate) A small amount of greens, kidney, liver, and powdered egg were supplied at regular intervals to supplement the standard diet Each animal of the control group (104X) was allowed 75 calories weekly, whereas the ration for the stunted group (103X) was only 42 calories These feeding conditions began at birth and continued through the period of 13 months preceding the beginning of the experiment, as well as throughout the training period The method of group feeding was employed, the proper amount of food for each group being readily consumed within the 20-minute feeding period The mice were all of the same strain, line, and age, hence were approximately equivalent in every respect

The results are indicated in Table 1. As will be seen, the record for the stunted group is markedly better than that for the control group in terms of trials to learn, and in time and error scores Since all other conditions were the same for the two groups, it seems fair to conclude that the increased efficiency of the stunted group was due to the long-continued dietary deficiency It was observed, moreover, that the animals of the stunted group were more active and vigorous than were the controls No evidence was secured bearing upon the manner in which a life of semi-starvation operates to influence favorably the rate of habit formation

TABLE 1

COMPARISON OF THE TWO GROUPS

Group	Number of animals	Average trials	Average seconds	Average errors
104X (control)	15	37.07	50 79	8 01
103X (Stunted)	16	27 44	37 99	6 56

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BEHAVIOR OF CASTRATED LIZARDS

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While studying the genital organs and behavior of both normal lizards (*Anolis carolinensis*) and those injected with whole gland sheep pituitary extract and Antuitrin S (1, 2, 3, 4, 5), a number of observations were recorded which reveal new facts pertaining to the behavior of castrates of both sexes.

These observations are significant since they throw some light on the nature of the territoriality urge and the fighting activities which are an expression of this urge It should be emphasized that normal female Anolis rarely fight (6) Over 150 normal females have been under observation in the laboratory and none have exhibited any of the fighting reflexes that are so characteristic of the male

A typical combat between males of this species is composed of a chain of reflexes which are expressed in temporal sequence (5) It is necessary to describe these briefly here in order that the behavior of the castrates be understood

The urge to acquire and to hold territory against other males is very marked The resident male, upon the approach of a strange male, will extend a dewlap or fan lying in the midventral line beneath the lower jaw (Reflex 1) This is a challenge or warning to the stranger If the latter does not reply to this challenge, no fighting is apt to occur although the resident male may persist in his challenging display for some minutes If the non-resident also flourishes his dewlap, then the dorsal crest along the neck of each male rises slowly to a height of perhaps 4 mm (Reflex 2) and they begin a sidewise approach toward each other (Reflex 3) while they flatten their sides to such an extent that the belly drags on the ground (Reflex 4) When they are within six inches of each other, they continue to strut back and forth with dewlap flashing and body flattened Many encounters end at this point The male that is most impressed with the display of the other moves off lowering his crest and withdrawing his dewlap, his body no longer flattened In other words, these four reflexes combine to produce an intimidating or bluffing effect often making it unnecessary to go farther to defeat a rival

However, if neither male is bluffed by this mutual display, their movements become swifter, they move closer, and opening their mouths wide each strives by means of swift snaps of the jaws to catch the snout of the other (Reflex 5) At last, the defeated male beats a hasty retreat (Reflex 6) while the victor pursues him for a short distance (Reflex 7) and then returns to a vantage point overlooking his territory and flashes his dewlap repeatedly (Reflex 8) The defeated male is not molested further unless he approaches the victor. In this case, a flash of the dewlap is sufficient to send the victim into hiding again

OBSERVATIONS OF CASTRATED FEMALE ANOLIS

1 August 4, 1934, about 11·00 a. m Sun shining A female was observed to be stretching up stiffly on its front legs while she rapidly extended and retracted her dewlap after the manner of a challenging male. On August 1, 1934, this female had been injected with one macerated mouse testis Autopsy showed atrophied ovaries.

2 January 25, 1935, 10·00 a m Sun shining brightly. Room temperature 80 F Witnesses Dr. L A. Walford and Mr. B Renshaw A female *Anolis* had received four male *Anolis* testes during the first week of June 1934 (Later autopsy revealed completely atrophied ovaries.) She was placed in a cage containing eight females, averaging 2 3 grams in weight, from which both ovaries had been removed during the first week of June, 1934 Within five minutes a large castrate approached the newcomer in the typical manner of a challenging male She extended her dewlap (which is much smaller in females than in males) and very quickly the stranger did likewise They sidled toward each other with sides flattened and dewlaps flashing Soon they were strutting around each other. Then they both opened their mouths wide and the resident female bit the newcomer repeatedly about the head and neck. The latter tried to do likewise but after fifteen minutes of fighting was finally defeated An hour and a half later, at 11:30 a. m, a second resident castrate approached the stranger in a similar manner to that of the first resident female The newcomer fled, seeking refuge among the leaves at the bottom of the cage. By 1 00 p m no further notice was taken of the stranger. At 2 00 p m a perfectly normal female was placed in the cage of castrates She was challenged by a castrate with the dewlap display but no subsequent fighting activity was observed. Thus we see that the resident female castrate follows the same fighting pattern and is influenced by the behavior of the non-resident exactly as the normal male.

3. February 1, 1935, 11.00 a m. Sun shining Room temperature 80 F. A large female castrate pursued a male *Anolis*, weighing four grams, so that he sought shelter behind a branch on the floor of the cage

4 February 5, 1935, 10:00 a. m. A female castrate, by her display of dewlap and strutting with sides flattened, intimidated a male, weighing 3.4 grams, so much that he finally ran from her approach.

5 February 28, 1935, 3 30 p. m. Sun shining Room temperature 80 F The following incidents show that a certain length of time must elapse after castration before the female behavior pattern is altered (*a*) One of the females castrated in June, 1934 was placed in a cage containing eight females which had been castrated on December 8, 1934[1] No interest was taken in the newcomer She was allowed to move about unchallenged (*b*) An hour later one of the female castrates of December 8, 1934 was placed in a cage containing the female castrates of June, 1934. Within three minutes, three of the resident females approached the stranger, even touching her with their noses One of the three took up the fighting pose; extended her dewlap, flattened her sides, and bobbed up and down. The strange female made no response to this display. Another one of the three began to bob and extend her dewlap. This caused the first resident female to pursue the second, while the strange female was allowed to remain unmolested.

6 April 16, 1935, 10 05 p m A large female castrate of June 1934 extended her dewlap, flattened her sides, and strutted before a male designated as *N* which advanced toward her The male promptly turned and moved away

7. April 16, 1935, 1 00 p m Mr L A Kleinholtz reported that two female castrates (December 8, 1934) threatened each other in a manner similar to that described above These two were killed a few hours later One of them had been bicastrated, the other still had a small part of one ovary although the other ovary and one adrenal gland had been removed

8 April 18, 1935, 8 30 a m While two normal males, designated as *P* and *K*, were fighting, a large bicastrate female (of June, 1934) climbed a near-by branch and extended her dewlap, compressed her body, and pursued another castrated female near by. It was not unlikely that the activity of this female was stimulated by the sight of the two fighting males

9. June 17, 1935, 11 45 a m. Male *AF* (normal in every respect) flashed his dewlap and turned quickly toward a female castrate of June, 1934 She responded by two flashes of her dewlap, then withdrew a few inches

10. June 17, 1935, 12 15 p m While males *AF* and *AC* (both normal) were fighting, a female castrate (of June 1934 but not the same referred to in case 9) climbed a branch about two inches above the floor of the cage and assumed the typical male fighting pose (extended dewlap, flattened

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[1] These females were kindly loaned by Mr L A. Kleinholtz

sides, bobbing the body up and down several times). She stopped for a moment then resumed for a few seconds more. It seems obvious that the actions of the females of case 9 and case 10 might be explained in a similar manner to case 8.

11. July 5, 1935, 11 15 a m Sun shining Room warm. A female castrate of June 1934 extended her dewlap, bobbed up and down on stiff legs with sides flattened A few seconds later she repeated the performance, moving slowly along the branch as she did so. This occurred after another female had been removed from the same cage at 11 10 a m.

OBSERVATIONS OF CASTRATED MALE *Anolis*

1. On September 2, 1934 two male *Anolis* (totally castrated July 26, 1934) were fighting fiercely with their teeth During this activity the dorsal crest of each male was about 2 mm. high. Both males displayed dewlaps and flattened their sides On December 11, 1934 one of these two males was seen strutting and fighting again with another male castrate

2 February 28, 1935, 3 p. m Sun shining Mr Kleinholtz described a fight which he observed between two males that had been bicastrated on December 8, 1934. Their behavior was precisely the same as that described for normal males (5).

3. April 9, 1935, 3 p. m Mr Kleinholtz reported that a large and a small castrated male (December 8, 1934) challenged each other with dewlap display and flattened sides.

4 The behavior of Male *N* has been described elsewhere (5). It should be emphasized here that this male was quite pugnacious in spite of the fact that he lacked one testis and the other was much reduced in size (as autopsy revealed)

CONCLUSIONS

These observations strongly suggest that the urge to fight in normal females is inhibited by the hormones secreted by the ovaries. Fighting takes place among females when the quantity of hormones secreted drops below the threshold of inhibition In other words removal of the feminizing effects of the ovaries radically changes the behavior of female *Anolis*

This fighting may arise through the expression of the territoriality urge (see cases 2 and 5) or it may be induced by imitating males which happen to be fighting in the vicinity (cases 8, 9, 10)

Not only has it been shown that castrated females fight, but there is evidence (cases 4, 5, 6, 8) that one such female will actually dominate over other lizards of the same species in the same cage

So far as males are concerned it is quite certain that fighting is not limited to normal males but may be indulged in by total and partial castrates as well

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EXPLORATORY EXPERIMENTS IN COLOR DISCRIMINATION

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A preliminary study of the ability of white rats to discriminate colored lights (2) suggested a number of problems which for the last three years have been under investigation in the Nebraska laboratory During that time the notion, popular among psychologists, that the lower mammals are color blind has not been accepted It would seem that if they are color blind, nature has been very inconsistent in giving color vision to the invertebrates and to the higher mammals and neglecting the inbetweens, the lower mammals

The studies reported here were initiated with the view of answering some of the questions raised concerning technique and indicating possible directions of research. From the various ones made in this laboratory, three have been selected which have contributed to the development of a new method In these studies four dogs, six cats, and eight rats were used Students trained especially for these studies acted as experimenters.[1]

In the reports of the original studies, the writer pointed out a number of flaws in Watson's technique, the most objectionable of which was that of training his animals to colored lights which were so very different in brightness value. Employing the chromopathometer, a standard discrimination box, and an improved technique, positive results were obtained which seemed conclusive at the time While the results of the later experiments have indicated the possibility of color vision, they have also revealed a possible failure of one of the control experiments In this control, after training the subject to distinguish colored lights, an attempt was made to confuse it by varying the brightnesses of both lights up and down the scale Care was exercised to remain within the limits of approximately 25 candle power, the original stimuli being rated at 546 c p. These changes produced radical brightness differences for the human eye and it did not seem advisable to chance *going below the animal's stimulus limen* It is possible, however, that in varying the brightnesses of each stimulus we did not at any time have the lights equated for the animal eye.

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[1] They were advanced students—Jean Campbell, Hugh Wyland, and Betty Baker, and graduate students—Ray Hackman, Robert Hall, and Robert Hardin

Munn recently has published an excellent criticism of the technique employed (1) His criticism of one of the control experiments coincides with some results which we have obtained However, his technique involving the use of a stimulus as weak as the one employed is questionable. Our colored patches were *19 times* more intense according to physical measurements. That meant that instead of working around a discriminal point, we were well above it It is entirely possible under the conditions of Munn's experiments that his animals simply ignored the colored lights which were of low stimulating value Another point to consider is that his stimuli were projected through the glass floor over which the animal ran, while the stimuli in the Nebraska apparatus were directly in front of the animal and at such a height as to be on a level with the rat's eye[2]

Munn's apparent rejection of the writer's findings on red vs darkness discrimination does not alter the results obtained His explanation is not satisfactory. Controls were exercised which indicated that discriminations *were* being made. Clearly the presence of the red light was necessary. However, contrary to the experiments of others working in this field, the changes were *very gradual* involving between three and four hundred trials This might account for the difference in results.

The experiments which have been conducted since the first work was done in this laboratory have been designed to reveal the factors which are important and contribute to differences in results when different techniques are used[3] The technique employed is the same as that used in any discrimination problem and has been described elsewhere by the writer (2) The usual control of secondary cues was observed Space will not permit a publication of the details of these studies, although the tables, graphs, and other data may be secured from the writer Experimenter No. 1 ran four animals upon the red-blue discrimination, introducing the controlled experiments without any evidence of emotional conditions arising in the animal The changes in brightnesses were made over a long period of time so that the animal might become adjusted to the new problem being introduced At the end of this period maximum changes in brightness could be effected without disturbing the behavior of the animal.

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[2] The tendency on the part of some critics to test one's theory and technique by an apparatus and method which differs so radically and to take negative results as proof of error is objectionable to some experimenters Munn's apparatus is being duplicated in the laboratory and experiments are being initiated to verify or refute his findings

[3] The ordinary controls in a discrimination project are well known and employed by any well-trained research worker As a matter of fact, many of these involve problems too difficult for the subjects to master On the other hand, the control situations many times are not properly presented to the animal with the result that a new problem is set up which requires time for mastery.

Experimenter No 2 trained his animals in the same manner, the subjects mastering the problem and behaving in a "normal" manner. Then the experiment was changed Instead of employing a long period of time for the brightness-control experiments, a short period was used, the changes from zero to the maximum of Experimenter No. 1's trials taking place in a single day Radical behavior[4] resulted, the animal becoming greatly confused, dashing back and forth in the cage and, finally, refusing to run Without exception, these radical changes in a single day produced this very unusual behavior The rats became useless as experimental animals. The same experimenter ran one rat to red versus darkness After 186 trials the problem had been learned Another hundred trials fully established the association between the red light and the getting of food Then the brightness of the red light was lowered, the changes being *very gradual* (a slight change each day) and continued over a long period of time Following this procedure a point was reached where the light was barely discernible to the experimenter who found it necessary to place his hands in the passage way to detect which was being used[5] Below this point the rat failed[6]

Experimenter No 3 employed the same technique as No 2 with the result that the rats simply refused to run when the changes were too radical However, in support of certain views which have been held, we did find that the animals were *more* affected by radical changes in the brightness of *blue* than of red. This might suggest that red was not being reacted to This was not true for when it was eliminated the animals trained to go to blue for food had less difficulty in selecting the correct path

Experimenter No. 7 worked upon four dogs[7] employing the technique originally developed in this laboratory. A discrimination box was built patterned after the one used upon the rat subjects but suited to the size of the larger animals. The source of stimulation was the same. Up to 876 trials the dogs failed to discriminate red from blue (the lights being equated for the human eye). However, at that point, the natural colored bulbs in the chromopathometer were changed from 60 to 100 watts. For the next 25 trials there was one error and for the next 50 trials no errors. From this time on the percentage correct varied from 80 to 100. Changing the intensities in random order *below* the brightness value of the original lights (546 c.p.) had no effect. Reducing the brightness of the blue light brought us to a point where the dog failed. This, however, was far below the brightness on which the animal had been trained before the substitution of the larger bulbs. Reducing the red to a point which was photometrically equal to the blue had no effect upon the behavior of the dog.

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[4] Some rather sensitive students of abnormal psychology object to the animal psychologist's attempts at classification The term experimental neurosis, however, has been used by men of recognized standing in the field.

[5] No apparatus was available for measuring the absolute point

[6] A failure which eliminates the possible use of any secondary cue

[7] The writer regrets that this very fine study by Dr Robert Hardin, then a graduate student in the department, cannot be given more space Publishing conditions are responsible for this condensing of his findings

This suggested the possibility that the dog either was not reacting to the red or that he was simply ignoring it since the blue was the positive light or the one which gave him food. Therefore, an experiment was set up in which the dog was forced to discriminate red from darkness by going to darkness for food. This was a new problem to the dog, and after 200 trials, the dog had not learned to make the discrimination. *Omitting the light caused the dog to refuse to run.* Reversing the problem, the experimenter broke down any habit which had been set up and taught the dog to go to red for food. Extra bulbs were necessarily inserted for the preliminary training and then removed for the usual tests on red versus darkness. Success on this part of the experiment indicated that the red light was perceived, and the fact that in the original problem changing the brightness of the blue light had affected the behavior of the animal while changing the red had had no effect simply suggested that it was *ignoring* what to him was no doubt a weak stimulus. It did not indicate that he could not see it.

The second dog employed on this experiment ran too rapidly, seemed to depend on the closing of the door for his cue,[8] and finally formed a position habit so strong that 150 trials, on each of which punishment was administered, failed to break the habit.

The third dog was trained to go to red for food when blue was present. The dog learned the problem in 640 trials after which blue was gradually eliminated with the result that the dog became greatly confused and did not learn the red-darkness discrimination after 210 trials. In the light of the first experiment upon dogs this result was difficult to understand. However, when blue-darkness was substituted the animal ran correctly to darkness. Then an explanation was possible. Here was an animal which in the original problem had learned to react negatively to the blue light and had simply ignored the red. The reaction of the first and third dogs seemed to be in terms of blue although number one had mastered the red darkness discrimination The conclusion drawn at this time was that dogs see blue with comparative ease while they see red with difficulty

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[8] As the dog entered the wrong compartment the door came shut with a bang, that shock being used in punishment.

The fourth dog gave no evidence at any time during a thousand trials that it could discriminate red from darkness In fact the dog behaved as if any problem would have been difficult. It is significant to the writer that if the results on dog No. 1 had not been obtained already, those on No. 4 would have been taken to indicate color blindness to red Apparently, this dog simply failed to sense the relationship between the red light and the getting of food The implication is that there are individual differences in the learning ability of animals All might learn the relatively simple blue-darkness discrimination but only a few, the more difficult red-darkness discrimination

Experimenters Nos 5, 6, and 7 were given pairs of cats upon which to perform the same experiment No 5 was given two white kittens, one of which readily learned the problem Then the brightnesses were changed until a point was reached where the maximum incorrect responses were being made. This point was taken to indicate brightness equality for the cat eye. This lowered the percentage correct from an average of 94 to 73 Beginning at this point 40 trials a day were run for twelve days making a total of 480 trials The results from this series showed for each 100 trials respectively, 72, 88, 78, 89 and, for the last 80 trials, 90 per cent correct responses. The last control consisted of eliminating each light one at a time Eliminating of blue resulted in a complete breakdown In fact, the animal was so completely upset that it tried to escape from the apparatus When the cat had been restored to normal behavior and a day had elapsed between tests, the red light was eliminated. *Exactly the same breakdown occurred* Obviously the cat was upset by the omission of either light The second cat had one blue and one brown eye, failed on the equated-intensities test, and would not be mentioned except for the fact that it behaved as did the first cat when the colored lights were eliminated in the colored light versus darkness tests

Experimenter No 6 was given two Persian kittens By the time the cats had run a thousand trials they had learned the problem The control experiments indicated that these cats were depending more on the brightness factor However, lowering the brightness of the blue for the cat trained to go to red for food resulted in the unexpected increase in correct responses This was contrary to the results which were obtained on the other animals being studied in the laboratory Lowering the blue to the point accepted by the other observers as being equal to the red in brightness for the cat eye had the effect of hindering the cat trained to go to blue for food and aiding the cat trained to go to red.

When the colors were eliminated one at a time, the cat going to blue for food was aided by eliminating red, the responses jumping to 90 per cent correct. The cat going to red for food decreased its accuracy, by the elimination of red, to 44 per cent. When blue was eliminated, the cat trained to go to blue for food was only 25 per cent correct in its responses, while the cat running to red for food increased his correct responses to 72 per cent It would seem that whenever the negative light is eliminated the percentage of correct responses increases

The last experimenter, No 7, was given two common gray cats When he had established the brightness equality of the colored lights for the cat eye he found the percentage correct dropped immediately However, he continued the experiment and after 200 trials the responses returned to 76 per cent correct in both cats When red was eliminated both cats showed an increase in the percentage correct and when blue was eliminated both cats showed a decrease in the percentage correct This indicated that one cat was running positively to blue and the other cat negatively to blue Both were discriminating the monochromatic light, red, from blue, the latter being its equal in brightness.

After an examination of Munn's technique and from exploratory experiments in the writer's laboratory, the following conclusions have been drawn

1. It is probable that the lower mammals have some form of color vision. the question is not settled, in fact, a great amount of research is suggested by these experiments

2 The emotional reactions of the animal may account for some failures· what the animal *will not* do cannot be taken to indicate what he *cannot* do.

3. Apparently interpretations of the animal's reactions must be based on a knowledge as to whether the animal was reacting positively or negatively in making his correct responses in the original training period

4 In the experiments mentioned here, there is evidence in the case of 11 out of 18 animals that they distinguished red from blue as color

5. In the control experiments it is imperative to introduce the brightness changes very gradually, radical changes upset the animal and, apparently, introduce an entirely new problem to him

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SEX DIFFERENCES IN RECALL OF STEREOTYPED DREAMS, SLEEP-TALKING, AND SLEEP-WALKING

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In this study an attempt has been made to investigate by means of a questionnaire (1) the frequency of recall of certain common or stereotyped dreams with special reference to the existence of sex differences, (2) the relation of subsequent dreaming to certain intensely unpleasant waking life experiences, (3) the frequency of sleep-talking and (4) sleep-walking Essentially we have sought to add to the factual knowledge of dreaming with only incidental concern for theoretical implications

PROCEDURE

A printed questionnaire was given to 559 subjects, all of whom were university students enrolled in courses in psychology. The group consisted of 228 men and 331 women of similar ages, the combined median age being 19 years and the lower limit being 16 years (three cases) The racial distribution of subjects was 541 white persons, 15 Orientals, and three Negroes. The intellectual status of the group is indicated by a median Otis Intelligence Quotient (Higher Examination Form A) of 119.

The use of the questionnaire was carried out as a routine part of the course work, hence, no selection within the group occurred To promote frankness and completeness in answering the questionnaire, subjects were instructed to sign their papers with pseudonyms and to take as much time in answering as they found necessary

A sample item from the questionnaire is given below·

8*a* Have you ever dreamed of flying, soaring, or floating in the air?

b If so, how frequently? (Estimate)

c Describe.

Typically for each item the subject was required to state whether he had ever had such a dream, the frequency of its occurrence, and description of the dream. For certain items, to be described later, additional information was sought Data of significance and interest will be presented under "Results" Although the questions were posed, "Have you ever dreamed of, etc.," they are clearly the equivalent of, "Do you now recall ever having dreamed of, etc" It is not our purpose to enter into a discussion of the factors influencing recall of dreams, but it is sufficient to state that the matter is even more obscure than that of the recall of waking life experiences[1]

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[1] For a discussion of memory for dreams, see Seashore (29, p 467) who says, "Only the exceptional dream is remembered" Calkins (6, p 312) says that "to recall a dream requires usually extreme and immediate attention to the content of the dream" Freud (10, p 35) calls attention to the proverbial statement that the dream "fades away" in the morning

The interpretation of our results involves the assumption that the frequency with which an individual dreams a certain stereotyped dream is a factor promoting recall of that dream That is to say, the more frequently a given dream has occurred to the individual, the greater is the probability of his answering affirmatively the inquiry concerning the dream From this standpoint our results should indicate the *relative frequency* of occurrence of certain dreams as compared with others, both in the whole group and in the sexes separately.

RESULTS

Some of our results are presented in the accompanying table and others in the following discussion. The items in the table are arranged in order of decreasing percentages of the whole group answering affirmatively The first column states the questions in abbreviated form, the second and third columns show, respectively, the percentages of the whole group replying "yes" and "no," and the remaining columns deal with sex differences. Columns four and five show the percentages of men and women, respectively, replying "yes"; column six, the critical ratio (C R),[2] and column seven shows the chances in 100 of a true difference greater than zero The criterion of a significant difference in terms of the critical ratio is within limits arbitrary, we shall follow the statement of Garret (13, p 133) in regarding a critical ratio of 3 or greater as indicating a reliable (sex) difference.

The table shows, in the first place, that all subjects reported having dreamed Eighty-eight subjects (or 15 7 per cent) stated that they dreamed every night, and at the other extreme two women subjects could each recall having dreamed only once in their lives[3] One hundred fifty-six subjects (or 27.9 per cent) could remember having dreamed the night previously to answering the questionnaire. Three hundred fifty-three subjects (or 63.2 per cent) stated that their dreams usually contained some reference to the experiences of the preceding day[4] Good evidence of the relationship of dreaming to stressful waking life experiences is found in the statement of 131 subjects (or 23.4 per cent) that they dream about examinations dur-

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[2] Calculated according to the formulae

$$\sigma_{diff} = \sqrt{\frac{pq}{n} + \frac{p'q'}{n'}} \text{ and } C\,R = \frac{\text{Diff}}{\sigma_{diff}}$$

[3] Berrien (3, p 195 f.) found no reliable relationship between the frequency of remembered dreaming and emotional instability as determined by the Thurstone Personality Schedule and the Colgate B2 Psychoneurotic Scale

[4] For an experimental study of the relationship of dreaming to recent impressions and a review of similar studies, see Malamud and Linder (18)

TABLE 1

PERCENTAGES OF THE TOTAL GROUP ANSWERING THE QUESTIONNAIRE ITEMS "YES" AND "NO," AND THE PERCENTAGE OF "YES" ANSWERS FOR THE SEXES LISTED SEPARATELY

Together with the critical ratios (C.R.'s) and the chances in 100 of true sex differences

Questions (abbreviated form) Arranged in order of decreasing percentages of the total group answering "yes" In items Nos 12, 13, and 20 "now" means "at the time of dreaming."	Total group $n = 559$		Separated according to sex of subjects			
			Men $n = 228$	Women $n = 331$		
Col I	Percentage answering "yes" Col II	Percentage answering "no" Col III	Percentage answering "yes" Col IV	Percentage answering "yes" Col V	Critical ratio $\frac{\text{Diff}}{\sigma_{diff.}}$ Col VI	Chances in 100 of a true sex difference Col VII
1. Ever dreamed?	100	0.0	100	100	0.0	50.0
2 Dream of falling?	87.1	12.9	86.4	87.6	41	65.0
3 Dream of being pursued by a person?	64.4	35.6	59.7	67.7	1.94	97.0
4. Dream of being pursued by an animal?	61.9	38.1	65.4	59.5	1.43	92.0
5. Wish-fulfilment dream?	59.9	40.1	60.5	59.5	24	60.0
6 Examination dream?	59.6	40.4	50.0	66.2	3.86	99.9
7 Dream of frustrated effort?	57.9	42.1	51.8	62.3	2.46	99.4
8 Dream of flying, soaring, or floating in air?	49.9	50.1	57.0	45.0	2.86	99.8
9 Dream of reptiles?	48.3	51.7	46.1	49.8	86	82.0
10 Dream of being hemmed in (enclosed)?	46.5	53.5	50.0	44.1	1.38	92.0
11 Dream of being inappropriately dressed?	45.3	54.7	39.1	49.5	2.45	99.4
12 Dream of a person, now dead, as alive (i e, as never having died)?	45.3	54.7	41.2	48.1	1.62	94.0

TABLE 1 (*continued*)

Questions (abbreviated form) Arranged in order of decreasing percentages of the total group answering "yes" In items Nos 12, 13, and 20 "now" means "at the time of dreaming."	Total group $n = 559$		Separated according to sex of subjects			
			Men $n = 228$	Women $n = 331$		
	Percentage answering "yes"	Percentage answering "no"	Percentage answering "yes"	Percentage answering "yes"	Critical ratio $\frac{\text{Diff.}}{\sigma_{diff}}$	Chances in 100 of a true sex difference
Col I	Col II	Col III	Col IV	Col. V	Col VI	Col VII
13 Dream of a person, now alive, *as dead*?	43.5	56.5	36.4	48.3	2.83	99.7
14 Dream of finding money?	40.6	59.4	44.3	38.1	1.47	93.0
15. Dream of your dying or being killed?	40.1	59.9	45.6	36.3	2.2	98.6
16 Problem-solving dream?	31.7	68.3	31.6	31.7	03	50.0
17. Dream of being nude?	30.6	69.4	39.5	24.5	3.75	99.9
18 Prophetic dream (i e, dream which came true)?	30.0	70.0	28.1	31.4	84	80.0
19. Dream of being a child again?	18.6	81.4	14.0	22.1	2.51	99.4
20. Dream of a person, now dead, as returned to life?	16.1	83.9	14.0	17.5	1.13	87.0
21 Dream of being an historical, legendary, or literary character?	14.9	85.1	20.2	11.2	2.84	99.7
22 Dream of being *some other person who is actually known to you*?	13.1	86.9	11.8	13.9	73	77.0
23 Dream of being an animal?	3.9	96.1	3.9	3.9	0.0	50.0

ing the nights of the examination periods.[5] Extreme stereotyping in dreaming was reported by one woman who stated that every dream was a "falling" dream, by another woman that every dream was a "flying" dream, and by a man that every dream was one of "frustrated effort" Three hundred seventy-six subjects (or 67.3 per cent) reported nightmares, and of these so reporting, 123 (or 32.7 per cent) stated that their nightmares were recurring stereotypes[6]

Of the particular stereotyped dreams inquired upon, dreams of falling were reported by the largest number of subjects (87 1 per cent) and dreams of being an animal by the smallest number (3.9 per cent) Reliable sex differences were found for only two stereotyped dreams, a significantly greater percentage of women than men reported "examination" dreams, and, conversely, a significantly greater percentage of men than women reported dreams of being nude (see Table 1, items number 6 and 17) Our result with reference to the sex difference in "nude" dreams is in agreement with Middleton (20, p 462 ff.). The sex difference found for examination dreams first requires confirmation

Overlapping of our categories of stereotyped dreams was frequently found; e g, one man dreamed of taking an examination in the nude, eight subjects in examination dreams found themselves unable to write (frustrated effort), many nightmares were dreams of being pursued by animals or persons, etc.

From the table (item number 16) it is seen that the percentages of men and women reporting problem-solving in dreaming are strikingly similar, 31.6 per cent and 31.7 per cent, respectively[7] For both sexes the kinds of problems were similar and were mostly connected with their scholastic work Prophetic dreams, i e, "dreams which come true," were reported by similar percentages of men and women, 28 1 and 31 4 per cent, respectively (item number 18). Such dreams are to be expected from the standpoint of the wish-fulfillment theory of dreams as well as other theories, e.g., the anxiety-fulfillment theory, the conflict theory, etc. Examples of prophetic wish-fulfillment dreams are such as dreams of amorous, scholastic, and athletic success. Typical of anxiety-fulfillment dreams are dreams of scholastic failure.[8] At least one subject qualified as an oracle by reporting (afterwards) that he had dreamed of an earthquake two days before one occurred.

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[5] Bagby (1) proposes that a study of dreams during periods of emotional stress, e g., period of engagement before marriage, affords a convenient test of the theory that dreams have their primary motivation in current emotional problems (Rivers' Theory) (28).

[6] For psychoanalytic theories of nightmares, see Brill (4, p 54), E. Jones (15, 16, p. 378) and Freud (12, p 42 ff). In the writer's opinion, Prince (25; 26, pp 431-442, especially p. 442) has given the most penetrating criticisms of psychoanalysis The writer concurs with Watt (32, p. 123) who says that "nightmares form a crucial test for any theory of dreams."

[7] In the questionnaire it was stated that the problems involved must be actual waking life problems Bechterev (2, p 44) cites the report of I I. Lapshin who mentioned more than 70 cases of "creativeness" in sleep. Prescott (24) has discussed the relationship of poetry and dreaming. The writer believes that there is much to commend in Havelock Ellis' statement (8, p 56), "In dreams we are always reasoning . That our reasoning is bad, often even preposterous, that it constantly ignores the most elementary facts of waking life, scarcely affects the question"

Relation of Intensely Unpleasant Experiences to Subsequent Dreaming. It has been variously stated that one who has undergone an intensely unpleasant experience is subsequently likely to dream about his experience, and particularly in dreaming to relive the experience (5, 7, 12, 14, 21, 22, 23, 27, 28, 30, 33). Especially has this been asserted with reference to the dreams of soldiers in wartime.[9] Thus Healey, Bronner, and Bowers (14, p. 67) say, "The clinical picture of war and other traumatic neuroses showed a striking peculiarity in the dream life—the patient continually dreaming of his disastrous experience."[10] Rivers (27, 28, p. 68) held the point of view that excessive repression prolonged the war neurosis and caused its expression in terrifying battle-dreams.[11]

We sought to investigate the relations of subsequent dreaming to two prominent sources of sudden unpleasant experiences, namely, serious accidents and earthquake experiences. With respect to accidents, 155 (or 26.7 per cent) of our subjects reported that they had been involved in "a serious accident, e.g., automobile, train, ship, or airplane accident, etc."[12] Of the 155 persons so reporting, 55 (or 35.5 per cent) stated that they subsequently dreamed of the accident. Of these 55 persons, 30 (or 54.6 per cent) reported recurring stereotyped dreams of the accident, and 36 (or 65.5 per cent) also reported that the emotion was the same in the dreams as in the accident. No reliable sex differences for any of the factors in the dreaming of accidents were found. One man stated that redreaming the accident always occurred "after a close call in driving." A woman reported that in the dream she takes the place of the woman whom she killed in an automobile accident; another woman reported that her dream is a "composite" (i.e., condensation) of two accidents.

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[8] Cf., von Hartmann's statement that (31, Part III, p. 67) "as for dreams, all the troubles of the waking life are prolonged into the dormant condition."

[9] Turner (30, p. 616) regards the recurrence of "terror dreams" as the outstanding symptom of the anxiety neurosis of warfare, and Core (7, p. 169) and Mott (23, p. 114) concur as to their decisive prognostic value. Wolfson (33, p. 180) found that "frightful dreams" occurred in 88 of 100 war neurotics.

[10] Freud finds the redreaming of this kind of experience to be an "exception" (10*a*, p. 38) and more recently a serious "difficulty" (12, p. 43 f.) confronting the wish-fulfillment theory of dreaming. In his recent *New Introductory Lectures on Psychoanalysis* (12, p. 43 f.), Freud says, "Only two serious difficulties face the wish-fulfillment theory of dreams, the examination of which leads us far afield and for which we have found no completely satisfactory solution. The first difficulty is presented by the fact that people who have had severe shocks or who have gone through serious psychic traumas (such as were frequent during the war, and are also found to lie at the back of traumatic hysteria) are continually being put back into the traumatic situation in dreams. According to our acceptation of the function of dreams, this ought not to be the case." (A critical review of this book can be found elsewhere, *Arch. Neur. & Psychiat.*, 1935, **33**, pp. 1135-1140). His best known works, however, apparently admit no exceptions to the wish-fulfillment theory (Cf., 10, pp. 103-112, especially p. 103 f.; 11, p. 190).

[11] Jones (17, p. 21 f.) points out the relatively small incidence of war neuroses among the total military population, and insists that the larger problem is the determination of the pre-disposing (i.e., pre-military) factors in such neuroses.

Our earthquake data showed that 490 (or 87.7 per cent) subjects had experienced an earthquake, mostly the Southern California earthquake of March 10, 1933. These 490 persons consisted of 193 men and 297 women, and of this group 60 men (or 31.1 per cent) and 145 women (or 48.8 per cent) definitely described their emotion as unpleasant,[13] thus indicating a reliable sex difference in the emotional response to the earthquake (C.R. = 4.01). Considering only those who experienced the earthquake *unpleasantly*, 23 (or 38.8 per cent) of the 60 men and 64 (or 44.1 per cent) of the 145 women reported that they subsequently dreamed about their experiences, and of those who so dreamed, 17 (or 73.9 per cent) of the 23 men and 44 (or 68.8 per cent) of the 64 women stated that the emotion was the same in the dream as in the earthquake experience. For those who experienced the earthquake unpleasantly sex differences in dreaming are not reliable. This is similar to the results of dreaming of accident experiences. We may conclude that our results with reference to the dreaming of earthquakes by those who experienced earthquakes unpleasantly and of serious accidents are *prima facie* evidence against the universality of the wish-fulfillment theory, and serve as partial support of the anxiety-fulfillment theory.

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[12] A serious accident was defined as one in which some person involved was killed or seriously injured. Most of the accidents described were typical traffic accidents, involving automobiles, street-cars, motorcycles, bicycles, and/or pedestrians. In addition, 33 accidents of other categories were reported: athletics (7), fire (6), horseback riding (3), airplane (3), falling from buildings (2), train (2), explosion (2), miscellaneous (8).

[13] Unpleasant emotional experience was described in such terms as "fright," "terror," "panic-stricken," "seasick," "end of the world," etc. Of those who experienced the earthquake but not unpleasantly, some enjoyed it ("amusement," "thrill"), others reported an undifferentiated excitement, and still others no emotional response ("indifference," "calm"). Franz and Norris (9, p. 112) have described the reactions to an earthquake of a group of over 300 persons of whom 132 "exhibited great fear (panic, paralysis, hysterical reactions) but a greater number who acted socially or with intelligence."

Sleep-Talking and Sleep-Walking Three hundred and forty-four (or 61 5 per cent) of the whole group gave a history of sleep-talking, comprising 129 (or 56 6 per cent) of the men and 215 (or 65 0 per cent) of the women This difference is unreliable (C.R = 2 14). Of those so reporting, 176 (or 51 2 per cent) stated that sleep-talking still persists. Our values are undoubtedly less than the true proportion of sleep-talkers in the group because one will give a history of sleep talking as a rule only if he has been informed of his behavior by some other person These results indicate that a history of sleep-talking should be considered normative, i.e, modal.

Sleep-walking,[14] as one might suspect, was reported by a smaller number of subjects, i.e, 117 (or 20.9 per cent) of the whole group The percentages for the sexes are remarkably similar; 45 men (or 19 7 per cent) and 72 women (or 21 9 per cent) so reporting (C.R = 0 63). This is in decided contrast with the greater frequency of stammering in males The median age at onset of sleep-walking was found to be 10 years, which is pre-adolescent and the same for both sexes Of those giving a history of sleep-walking, 10 (or 22 2 per cent) of the 45 men and only 3 (or 4 2 per cent) of the 72 women stated that the performance exists at present This is in the direction, but inconclusive, of a significant sex difference (C R = 2 72), and may be related to the latter adolescence of males as compared with females It is, however, futile to speculate as to the possible significance of this and several other findings described in this paper unless they are confirmed by other investigators

SUMMARY

By means of a questionnaire sex differences were investigated with respect to the recall of (1) certain common or stereotyped dreams, (2) the relation of certain intensely unpleasant experiences to subsequent dreaming, (3) sleep-talking and (4) sleep-walking For only two stereotyped dreams were reliable sex differences found, namely, a significantly larger percentage of men dreaming of being nude, and a significantly larger percentage of women having "examination" dreams For the relation of unpleasant experiences to subsequent dreaming, and for sleep-talking and sleep-walking, no significant sex differences were found

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DELINQUENCY AND READING

PAUL FENDRICK AND GUY BOND

I. INTRODUCTION

Dr William Healy, writing on the rôle of our public schools in a program for the prevention of delinquency, states (3) that school maladjustments and dissatisfactions are at the root of a considerable number of delinquent careers He believes, furthermore, that school people do not sufficiently realize their potentialities for the reduction of delinquency Dr Healy has had a wealth of experience in this field and is acquainted with the multitude of factors whose effects are so difficult to gauge in the development of cases of social maladjustment.

Dr Nathan Peyser (6), member of the Commission of the Governor of New York for the Study of the Educational Problems of Penal Institutions for Youth, in a study based upon surveys carried out in the New York City Reformatory and the House of Refuge on Randall's Island in New York City, points out the high incidence of school retardation in the delinquent groups studied and suggests common causative factors underlying school retardation and delinquency He writes:

> School failure appears to be more highly correlated with the incidence of delinquency than is any other condition, including

> poverty, broken home, absence of religious association, physical defect, mental defectiveness, psychopathic condition, or truancy Failure is written large in the school histories of the great majority of the boys.

Dr Peyser then presents data indicating that 29 per cent of New York City elementary school children were retarded and that these children have contributed from 84 4 per cent to 92.8 per cent of the delinquent groups which he investigated. He then concludes

> Assuming the basic fact of common underlying causative conditions, we must reach the conclusion that a broad attack in the schools upon retardation and its underlying causes will reach the factors responsible for maladjustment of which delinquency is but one expression and retardation another.

With this prominent sponsorship emphasizing the school background as associated with delinquency, the next logical phase of inquiry appeared to lie in an investigation of the factor or factors in the school situation that might accompany the evolution of the young offender Mr George H Chatfield, Director of the Bureau of Attendance of the New York City Board of Education, states[1] that "no small portion of delinquency and social and emotional maladjustment may be traced to frustration originally caused by difficulty or failure in the early stages of reading"

Already school experience and scientific research have introduced a great deal of evidence regarding the prime importance of reading in school work Percival (5) found that failures in the primary grades are almost wholly due to deficiencies in reading, Lee (4) has demonstrated that a certain minimal amount of proficiency in reading is essential for the maintenance of normal progress in the other school subjects.

The above evidence introduces a conjecture regarding the reading status of well-defined delinquents If failure to learn to read adequately is related to delinquency, then a population of delinquents would be expected to show markedly inferior attainment in reading.

II NATURE OF PRESENT STUDY

An occasion[2] presented itself so that a study of delinquents could be made in an institution located in New York City Commitments to the House of Refuge[3] located at Randall's Island, New York City, are made of male persons 16 years of age or over, but less than 19 years of age, by any competent court in the state for any offense except those punishable by death or life imprisonment. Although there was a predominance of commitments from New York City on the island, the population was composed of inmates committed from the entire New York State area. Of this delinquent group in the House of Refuge, over 90 per cent had been school failures

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[1] New York World-Telegram, May 27, 1935

[2] The authors are exceedingly indebted to Mr D D Scarborough, Director of Education in the House of Refuge, for permission to conduct this investigation In addition, the senior author, through a semester's teaching experience at this institution, was able to procure much first hand information regarding its academic mechanics

[3] Transferred April 15, 1935 to West Coxsackie, N. Y and now called the New York State Vocational Institution

An eight-minute test, Type C—Reading To Understand Precise Directions—of the Gates Silent Reading Test battery (1), was selected as the most appropriate and expedient device for the situation at hand. This test appeared sufficiently appropriate for our purposes inasmuch as it seemed to gauge such skills as are requisite for mastering the fundamentals for the journeyman in the several arts and crafts According to Professor Arthur I Gates (1), Type C Test measures a type of reading which is very essential in understanding arithmetic problems and in following directions for using objects and obtaining all sorts of informative material This test has been adequately standardized (2) and the norms exist for determining the chronological equivalents for various degrees of test attainment

The test was given to 11 class groups approximately representing the total and available population in the House of Refuge At the time, there were approximately 260 boys in the institution. The results of the present study are based upon 187 cases A population sampling was obtained from boys assigned to such classes as sheet metal, tailoring, machinery, cooking, building trades, printing, and the sixth, seventh, eighth, ninth, tenth, and eleventh academic grades

The boys were told that the tests would in no way jeopardize their institutional status and that the only purpose was to ascertain how well they could read. This information was necessary, they were informed, in order that greater benefit might accrue to them in their subsequent institutional training. It might be mentioned in this connection that all the boys had already been exposed to some psychological testing, and considerable precaution was taken to avoid the suspicious concomitants that were associated with the "bug" tests[4] Assurance was given that the present tests had no relation with any previous "bug" tests, their purpose was primarily to guide the staff in procuring more interesting books and other literature[5]

The examiner who administered the reading tests had already established a rapport with the boys The cooperation of these boys was excellent; better, in fact, than might have been anticipated under the existing circumstances. Inasmuch as the boys had associated psychological testing with transfer to other institutions, there existed some antipathy to any devices related to their potential segregation The examiner felt that this peculiar state of affairs compensated for such indifferent attitudes as might prevail under ordinary testing conditions.

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[4] Appelation coined by the boys for tests previously given by the psychologist in the institution.

[5] It might be mentioned that such current magazines as the *New Outlook*, *Literary Digest*, *Current History*, *Scientific American*, *Review of Reviews*, and *Scribners* were on the institutional subscription list and served as supplementary reading material.

With the measurements of the reading status effected, the official records of the institution were examined for each boy's mental and chronological age. Binet scores were recorded for approximately one-half of the boys and mental ability ratings procured from the Otis Self-Administering Tests (Intermediate Examination) were available for practically all[6] of the boys. These data will be reported in conjunction with the reading results.

III. RESULTS

Figure 1 shows the various degrees of mental ability evinced by the delinquent population whose reading performance was under investigation Inasmuch as Binet ratings were not available for the entire group, the incidence of mental alertness is reported by means of a group percentage distribution chart A superficial examination of the frequencies does not appear to uncover any marked variation between the individuals measured by the Otis test or the individuals measured by the Binet test. The mean score

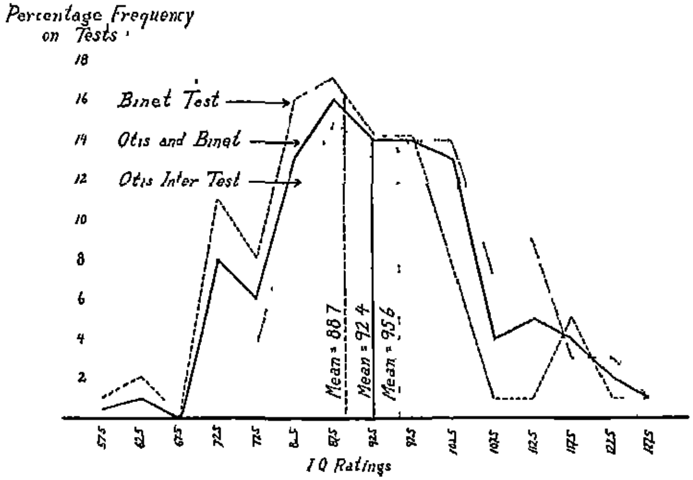

FIGURE 1

PERCENTAGE DISTRIBUTIONS OF MENTAL ABILITY RATINGS ON 185 DELINQUENTS INVESTIGATED FOR READING ABILITY AT THE HOUSE OF REFUGE

(Randall's Island, New York City)

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[6] At the writing of this report, there were two cases whose mental ratings were unavailable In addition, there were 26 cases whose records indicated measurements on both the Otis and Binet scales

on the Otis instrument for 98 cases is 95.6, while the mean score on the Binet instrument for 87 cases is 88.7.

There were 26 cases which were reported in the institutional records with both the Binet and Otis IQ ratings. These dually measured boys have a mean IQ of 83.3 on the Otis scale and 85.4 on the Binet scale. From this and other evidence, it appears that the institutional testing was particularly cautious. Inasmuch as boys of low grade mentality were not confined at the House of Refuge, but were transferred to a state institution for defective delinquents, those indicating a greater likelihood for a low mental age were given the Binet test. The evidence already reported tends to substantiate this position.

The previous discussion is pertinent inasmuch as the Otis instrument is considerably influenced by relative adequacies (or inadequacies) in reading attainment. The Stanford-Binet test is influenced to a lesser degree by reading proficiency and would have been the preferable basis for relating reading attainments to intellectual status.

Notwithstanding these varying conditions, Figure 1 presents a fairly good Gaussian distribution. The mean rating of 92.4±0.7, although lower than the mean of a random group, does not seriously affect the principal findings, particularly, when this difference is contrasted with the subse-

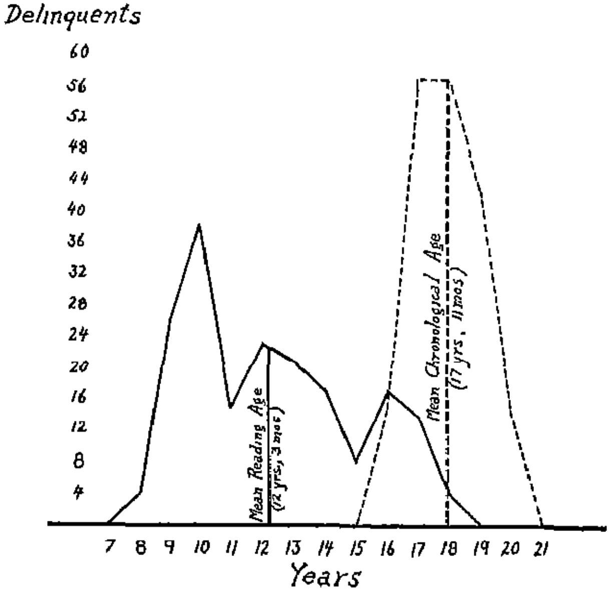

FIGURE 2

READING AGES AND CHRONOLOGICAL AGES OF 187 DELINQUENTS quently reported group reading performance, the loss in the general level of mental status can be discounted

Figure 2 supplies the data critical to the general theme of the present study. The marked dichotomy between the reading and chronological ages is self-evident The mean reading age for the entire population is 12 years and 3 months while the mean chronological age for the same group is 17 years and 11 months. The disparity of 5 years and 8 months between the chronological and reading ages is quite serious. Its significance is of definite import to all educators, social workers, psychologists, criminologists, and society-at-large. This finding is merely symptomatic to be sure, but the evidence is objective and derived from a diagnostic attack on an extremely select group.

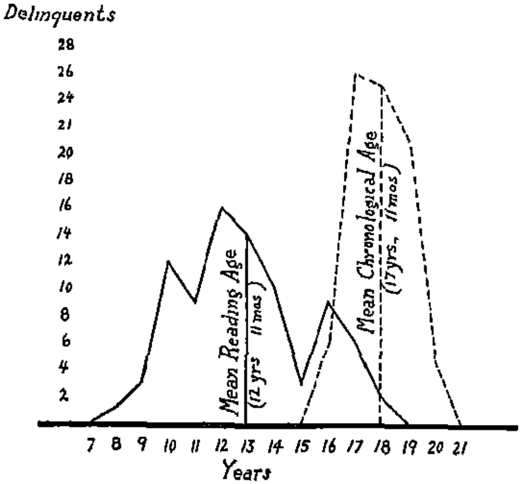

FIGURE 3

Reading Ages and Chronological Ages of 83 Delinquents with 90-110 I Q Performance

Figure 3 presents the relationship between chronological and reading ages for those delinquent boys with an IQ range from 90 to 110. These ratings were compiled from the Otis and Binet tests which, strictly speaking, involve a classification on basis that is not exactly reliable because of the influence of the verbal factor In spite of this influence, however, a mean[7] difference of five years exists between the chronological and reading status of this population This finding tends to confirm the hypothesis that something else besides intelligence was working to effect the retarded condition.

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[7] *The mean chronological age is 17 years and 11 months while the mean* reading age is 12 years and 11 months

A few Pearsonion coefficients were computed with regard to the relationship between mental and reading abilities. They are contained in Table 1.

TABLE 1

Cases	Tests	Correlation
All boys with Binet records (N=87)	Binet and Gates Type C Reading	0 56±.05
All boys with Otis records (N=124)	Otis and Gates Type C Reading	0 62±.04
Twenty-six boys with Otis and Binet records	Binet and Gates Type C Reading	0 39±.11
Twenty-six boys with Otis and Binet records	Otis and Gates Type C Reading	0.59±.09

Table 1 gives indication of a higher degree of relationship between the Otis mental ability and the Gates Reading tests than that effected through a Binet-Gates correlation. This evidence confirms a priori expectations positing the reading factor as being integrated more highly with the Otis instrument than with the Binet scale.

These findings demonstrate that our delinquent population was quite markedly retarded in reading ability Although these data do not define the quantitative influence of reading maladjustment upon delinquency, there is ample evidence of marked association between these attributes. Mr. G. H Chatfield,[8] who has already been quoted regarding his belief on the relationship between reading and delinquency, believes that "it must be made possible for a child to succeed in school work so that he will want to go to school instead of running away from it" He reports a very definite trail from truancy to delinquency.

Evidence from recent investigations[9] demonstrates that, with favorable conditions for reading instruction, there is little justification for the existence of much of the present reading inefficiency While our present findings point to a strong relationship between school maladjustment and delinquency, the crucial test for this association lies in the elimination of these school failures and then studying the effects in terms of delinquency This attack is obviously a long-time project but should merit attention

The import of this problem can be inferred from a statement recently made by Dr. E T. Glueck[10] of the Institute of Criminal Law at Harvard University. Glueck alleges that "at least 200,000 children of America today will soon be joining the criminal ranks" She reports an intensive study of 1000 juvenile offenders as indicating that the average age at onset of delinquent behavior is 9 years and 7 months so that, obviously, the indicia of delinquency must have been evident during school years. Eighty-five per cent of the offenders in her study gave evidence of anti-social behavior in school Dr Glueck concludes that her findings place at the door of the school the responsibility for the early recognition of delinquency and, at least, participation in a treatment program

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[8] *New York Times*, March 17, 1935

[9] Unpublished data of Prof A. I. Gates on remedial reading training in New York City schools

[10] *New York Times*, March 17, 1935.

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THE ABC TESTS: A METHOD OF VERIFYING THE MATURITY NECESSARY TO LEARN HOW TO READ AND WRITE

M Bergström Lourenço, filho

The application of the ABC Tests to more than forty thousand illiterate children in Brazil shows promising results bearing on the problem of homogeneous grouping according to the ability to learn how to read and write Since the high correlation with the final outcome of the school year proved the efficacy of the ABC Tests as a means of classification, we thought it might be of interest to give a short description of how the tests were selected and standardized, and how they led to a greater efficiency in teaching and learning

Psychological Principles Involved in the Choice of the ABC Tests

The low correlation between the IQ and the ability to learn how to read and write led to the practice of regrouping beginning school children after several weeks of schooling This long delay caused the slow child to form wrong emotional attitudes towards the school, on acount of the unavoidable criticism of abler companions Furthermore, experience proved this procedure to be inaccurate and wasteful Such difficulties induced us to seek a method of diagnosing the ability to learn how to read and write at the beginning of the school year

We based our study on the following well-known psychological principles In reading, the visual stimulus of the printed or written word incites verbal reactions instrumental in the recall of meanings Openly expressed articulation and its reduced form involved in thought are the result of subtle and complex motor coordinations Besides these reactions of speech, reading also includes delicate muscular adjustments of vision Among these are certain eye-movements necessary in the discrimination of form. Writing involves reading and adds to the reactions necessary to the latter obvious muscular coordinations of the arm, hand, etc

Since reading and writing involve numerous and delicate muscular reactions, an adequate physiological maturity is the indispensable basis for the acquisition of these skills. The degree of maturity may be verified for our purposes by measuring the ability of the child in performing simple tasks, such as the copying of two dimensional figures. In choosing the tests we took into consideration that the active processes of reading or writing constitute a functional whole They are interrelated to such a degree that it is impossible to test them separately or analytically Hence the necessity for a synthetic method

A synthetic test may consist in giving the child an opportunity to attempt the performance of the skill itself Thus, in writing it would imply the copying of words or letters But since experience proved this to be an inaccurate means of classification, we were led to choose tests presenting analogous situations, which would bring out clearly the critical aspects of the problem

The originality of the ABC Tests lies not in their form but in their choice and combination and the purpose for which they are used Among tests of wide application and well-established technique the author chose such as had a direct bearing on the diagnosis of the maturity necessary to learn how to read and write Thus he took from Binet-Simon the copy of the square and diamond, and from Toulouse Piéron the memorization of commonly used words.

From an initial list of twenty tests only eight considered as absolutely essential were retained. In this choice preference was given to those involving a simpler technique and requiring less expensive material The low correlation of the remaining eight with one another proves that each test has a specific function[1]

Due to the fact that the tests were used in a new combination and for a new purpose, slight adaptations were necessary. A few changes were introduced into the original technique In some the wording and the directions were put into a clearer form, and the method of scoring was made uniform. Each test was classified as poor, inferior, medium, and superior, the scores 0, 1, 2, and 3 being given respectively This arrangement fixed the extent of variation between 0-24 grade points

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[1] The coefficients of correlation are shown in (1, Table 1, p 69)

SHORT DESCRIPTION OF THE TESTS

Test 1 Paper and pencil is given to the child who is asked to copy three *two-dimensional figures a square, a diamond and an irregular outline.*[2] This test shows the degree of visual motor coordination.

Test 2. A chart with the pictures of seven familiar objects is shown for 30 seconds. When the time is up the figures are hidden and the child is asked to name the things he has seen This test measures the visual memory span and is helpful in the study of the child's vocabulary.

Test 3 *With his finger the examiner draws in the air three two-dimensional* figures The child is asked to reproduce the movements as he has seen them and then to draw them on paper. The direction of the movement *is the important aspect of this test. It shows whether the child is* able to resist inversion in the copy of figures

Test 4 The examiner enumerates seven familiar words and asks the child to repeat them This test measures the auditory memory span, and the accuracy of pronunciation

Test 5. The child is told a simple story about the breaking of a doll and is asked to reproduce it This test, measuring the accuracy in the remembrance of the main actions and details, helps in the study of the child's general understanding, besides furnishing valuable facts about the use of words

Test 6. The child is asked to reproduce one by one ten unusual words of several syllables, such as Constantinople This test measures the capacity of enunciation

Test 7 A pair of scissors is given to the child, who is asked to cut out, as rapidly as possible, first an angular and then a sinuous line.[3] This test measures the accuracy of visual motor coordination and the degree of directed attention

Test 8 The child is given a paper ruled in squares and is asked to make a dot in each square as quickly as possible, 30 seconds being given for the performance of this task This test measures the ability of the child to resist fatigue *and is a further index of directed attention*

THE STANDARDIZATION OF THE ABC TESTS

The result of the first extensive application in S. Paulo[4] is significant, as can be seen from the following figures

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[2] The figures of Test 1 are shown in (1, p 126)

[3] *The figures are shown in (1, p 133)*

[4] The frequency curve of the first extensive application (1, p 74).

In the normal curve the mean, median, and mode coincide In the curve obtained they approximate each other closely·

Mean	13.98
Median	14 44
Mode	14 00

The measures of variability are satisfactory

Mean deviation	2 10
Standard deviation	2 66

The following figures show how the mean and standard deviations of the curve obtained compare with the normal curve

	M D	S D.
Normal curve	57 50% of cases	68.26% of cases
Curve of first application	64.00% of cases	73 50% of cases

The semi-interquartile range and the probable error which coincide on the normal curve approximate each other closely on the curve obtained.

Q.	1 82
P.E.	1 79

The P E of the mean was only 0 06 and the skewness 0.51.

The above result of the first application showed that the ABC Tests are a reliable method of measurement. Subsequent applications have confirmed this conclusion. The second time the tests were used in S. Paulo 15,605 children were examined. The third time they were given at 2410 of the Federal District

The results of the first and second applications are listed below for comparison.[5]

	Number of cases	Mean	Median	Mode
First application	810	13 98	14 44	14 00
Second application	15,605	13.97	13.89	14 00

	A.D	S D.	Q.D	P E
First application	2.10	2 66	1 82	1.79
Second application	2 08	2 63	1 82	1.80

Some of the results of the first, second, and third applications are listed below:

	Number of cases	Mean	Median	S.D.	Q.
First application	810	13.98	14 44	2 66	1 82
Second application	15,605	13.97	13 89	2.63	1 82
Third application	2410	13.22	13 59	2 41	1.77

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[5] Frequency curve of first application p 74, second application p 79 (1)

LOW CORRELATION WITH THE CHRONOLOGICAL AGE

The following results were obtained from separate application to each chronological age. The averages for each age from 7 to 13 are listed in Table 3 on page 81 (1). The close approximation of these averages shows that the ABC Tests do not possess a significant relation to chronological age The same fact is demonstrated by the frequency polygons on page 83 and by the coefficient of correlation which is only 0.22±0 08.

Following Claparéde's criterion we reached the following conclusion *Since the differences between the medians of the successive ages is less than the quartile deviation, the ABC Tests show no significant relation with chronological age*

Ages	7-8	8-9	9-10	10-11
Differences between the medians	1.06	0 30	1 64	0 42

All these differences are inferior to the quartile deviation which equals 1.77.

LOW CORRELATION WITH MENTAL AGE

ABC and Binet-Simon	0.17±0 09
ABC and Pintner-Cunningham	0.35±0.137
ABC and Goodenough	0 15±0 053

As can be seen from the figures the correlation with mental age is too low to be of significance.

POSITIVE CORRELATION WITH THE RESULTS OF THE SCHOOL YEAR

The accuracy of the tests in classifying children according to their ability to learn how to read and write was evident during the school year and at the end the results were the following For example, at the Barra Funda School in S Paulo tests measuring the speed and accuracy of oral and silent reading, and the speed and perfection of writing showed with the ABC Tests a correlation of 0 75±0 26 Another typical example is that of Bello Horizonte, Minas Geraes Tests measuring skill in reading and in writing reached the significant correlation of 0.61±0 04 Samples of writing at the end of the school year are reproduced on pages 124 and 125 The superiority of the first group of children over the second is evident

PRACTICAL RESULTS OF THE ABC TESTS

An important practical result of the ABC Tests is the increase in promotions at the end of the school year. In 1931, when the tests were applied to 15,605 children in S. Paulo the gain was 18 per cent of the total and approximately 30 per cent over the results of the three preceding years A detailed account is given in Table 7 on page 104 (1). The general averages were the following

1928	1929	1930	1931
62.02	63.16	64 60	81 97

The promotions increased in all schools in which the ABC Tests were used In only nine out of 54 schools the gain was less than 5 per cent It is interesting to compare the figures listed below

Number of schools	Increase in promotions
12	More than 25%
8	More than 20%
12	More than 15%
7	More than 7%
6	More than 5%
9	Less than 5%

Special corrective work can be used to great advantage. In the practice school of S. Paulo the following experiment was made To one of two groups classified as inferior by the ABC Tests regular school work was given The second group received corrective training in the form of oral games, clay-modeling, drawing, etc. The class helped with special difficulties at the end of two months of schooling reached and surpassed the other which had been working for six months. At the end of the school year the difference was even more striking. Another advantage of homogeneous grouping is that fast learners may be promoted to the second grade after the first semester, thus cutting the expense in half The great increase in promotions also represents a financial gain

In conclusion it might be said that the ABC Tests allow the school work to be adapted to the capacity of the child. The slow need not hurry in trying to keep up with fast learners, and superior children keep interested in their work and do not disturb the discipline of the class. This of course means an easier task for the teacher, and more efficient learning on the part of the pupils.

RESULTS OF RECENT APPLICATION IN THE FEDERAL DISTRICTS, RIO DE JANEIRO

In March 1934, the beginning of the Brazilian school year, all first grades of the Federal District were organized according to the ABC Tests. The number of children examined equaled 22,115.

The statistical results are in accordance with previous applications. Thus, for instance, the correlation with the chronological age did not surpass 0 33±0.004.

Tests in reading and writing given at the end of the school year in November showed a high correlation with the diagnosis of the ABC Tests, and the promotions increased in average 15 per cent The results will soon be published by the Department of Education, Rio de Janeiro.

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Instituto de Educação
Rio de Janeiro, Brazil

APPARATUS

A COMBINATION OF PEG BOARDS

MARIE L H FORBES

The purpose of the note is to describe a combination of fixed pegs and perforated cards.

The device consists chiefly of fixed pegs with perforated cards or rings for combination with them It may include inset-boards and coin-cards.

The drawing (Figure 1) in perspective shows detachable circular boards with pegs fixed to represent an equilateral triangle, a square, and a pentagon, the pegs being three-sixteenths of an inch in diameter, and cards with punches one-quarter of an inch in diameter to be combined with them.

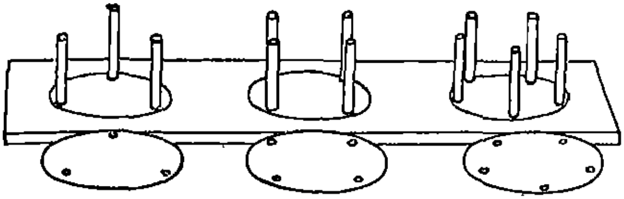

FIGURE 1

The mechanical drawing (Figure 2) shows boards designed with holes

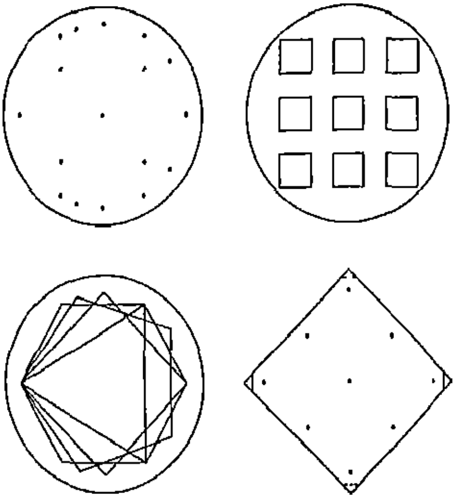

FIGURE 2

in a nine-hole square admitting of arrangements shown in Table 1 or in symmetrical geometric patterns as shown in the drawing in perspective

The writer gratefully acknowledges the examination of the device by her former instructor Dr. Walter F Dearborn, Director of the Psycho-Educational Clinic of Harvard University.

TABLE 1

Perforations in Cards for a Nine-Hole Board

	a	b	c						Board
Group 1	1 – – – – – – – –	– 2 – – – – – – –	– – – – 5 – – – –						1 2 3 4 5 6 7 8 9
	a	b	c	d	e	f	g	h	
Group 2.	1 2 – – – – – – –	1 – 3 – – – – – –	1 – – – 5 – – – –	1 – – – – 6 – – –	1 – – – – – – – 9	– 2 – – 5 – – – –	– 2 – – – 6 – – –	– 2 – – – – – 8 –	
	a	b	c	d	e	f	g	h	
Group 3	1 2 3 – – – – – –	1 2 – 4 – – – – –	1 2 – – 5 – – – –	1 2 – – – 6 – – –	1 2 – – – – 7 – –	1 2 – – – – – 8 –	1 2 – – – – – – 9	1 – 3 – 5 – – – –	
	i	j	k	l	m	n	o	p	
	1 – 3 – – – 7 – –	1 – 3 – – – – 8 –	1 – – – 5 – – 8 –	1 – – – 5 – – – 9	– 2 – 4 5 – – – –	– 2 – 4 – 6 – – –	– 2 – 4 – – – – 9	– 2 – – 5 – – 8 –	
	a	b	c	d	e	f	g	h	
Group 4.	1 2 3 4 – – – – –	1 2 3 – 5 – – – –	1 2 3 – – – 7 – –	1 2 3 – – – – 8 –	1 2 – 4 5 – – – –	1 2 – 4 – 6 – – –	1 2 – 4 – – – – 9	1 2 – – 5 6 – – –	
	i	j	k	l	m	n	o	p	
	1 2 – – 5 – 7 – –	1 2 – – 5 – – 8 –	1 2 – – 5 – – – 9	1 2 – – – 6 7 – –	1 2 – – – 6 – 8 –	1 2 – – – 6 – – 9	1 2 – – – – 7 8 –	1 2 – – – – 7 – 9	
	q	r	s	t	u	v	w		
	1 2 – – – – – 8 9	1 – 3 – 5 – 7 – –	1 – 3 – 5 – – 8 –	1 – 3 – – – 7 – 9	– 2 – 4 5 6 – – –	– 2 – 4 5 – – – 9	– 2 – 4 – 6 – 8 –		

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A COMBINATION OF HORN-BOOK AND TYPEWRITER

Marie L. H. Forbes

The purpose of the note is to describe a combination of a chart with letters and a one-row typewriter keyboard.

The combination consists of a board or card attached in a vertical position to a typewriter behind a single row of keys (3), letters in the lower margin of the board serving as indices to the keys, which are blank The board has attached to it hooks or loose-leaf note-book rings for additional cards. An old model of type-wheel machine with keyboard, as shown on the chart, may be used without removal of keys, the chart being attached just behind the lowest row of keys.

Although adaptable to a variety of uses if items other than letters appear on the chart, the combination as described is intended for use in connection with training in word recognition, in cases requiring large type.

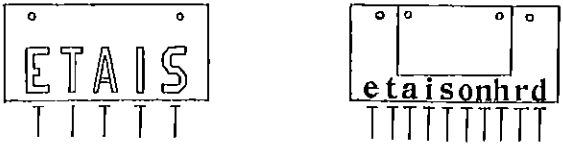

FIGURE 1

One of the advantages of typewriting for non-readers mentioned by Dearborn (1) is "the training of the eye to follow the correct sequence of letters." If a certain procedure is adopted, this combination might, in the opinion of the writer, furnish this type of training.

A word printed in large type is to be covered by a card held in the teacher's hand, then uncovered letter by letter as the child finds the letter on the chart and presses the key under it.

This procedure, already described in connection with alphabet-insets (4), applies also to printing cubes (2). As a training device the printing cubes are

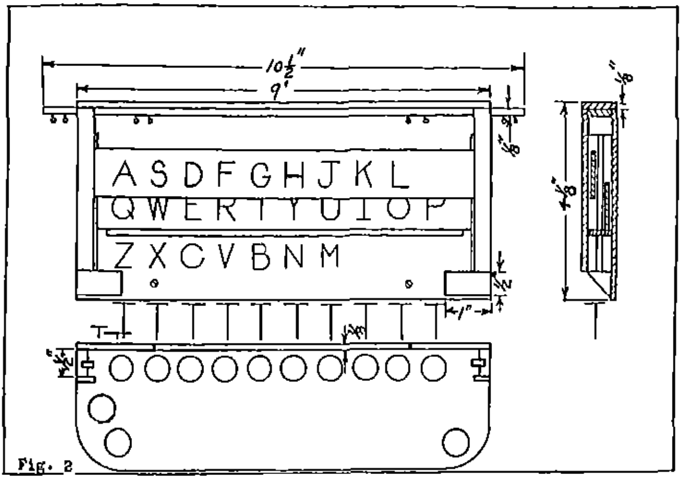

Fig. 2

FIGURE 2

superior to the typewriter, for the child using large type, in that they offer him an opportunity to examine his work as he goes along But as a recording device the typewriter is superior, since it registers the order of the child's choices, a matter difficult to judge when one letter has been stamped over another

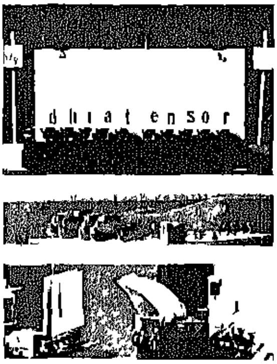

FIGURE 3

In the absence of a typewriter, the writer suggests, for training purposes, a wooden model of a one-row keyboard of blank keys to be used with a chart, a simplification of the wooden keyboard shown in the photograph, in which blocks are attached to levers which are strung on a rod resting on blocks on a platform

The writer gratefully acknowledges the examination of the devices by her former instructor, Walter F Dearborn, M D, Director of the Psycho-Educational Clinic of Harvard University

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THE TYPEWRITER KEY AS A DEVICE FOR REGISTERING CHOICE

Marie L. H. Forbes

The purpose of the note is to describe a modification of the combination of horn-book and typewriter described in a previous note in which items other than letters serve as indices to blank keys.

The drawing represents a card to be attached to a typewriter behind a row of numeral keys from which several have been removed, the card having in its lower margin forms, colors or other samples for matching. The forms shown are those selected by Gesell from Kuhlmann's form cards as described by Terman modified and adapted for us with a typewriter keyboard

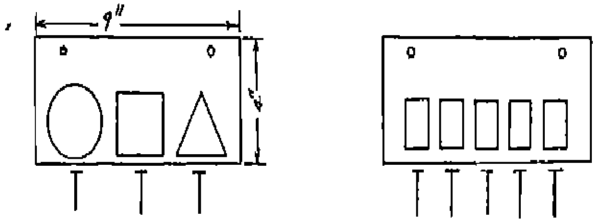

FIGURE 1

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BOOKS

ARNOLD GESELL. *An Atlas of Infant Behavior A systematic delineation of the forms and early growth of human behavior patterns* Vol. I (in collaboration with Helen Thompson, and Catherine Strunk Amatruda)· Normative Series Vol II (in collaboration with Alice Virginia Keliher, Frances Lillian Ilg, and Jessie Jervis Carlson) Naturalistic Series New Haven Yale Univ. Press, 1934 Pp 1-524, 525-922.

This work presents two series of studies of the behavior of human infants through the first 56 weeks of post-natal life, a normative series, presented in Volume I; and a naturalistic series, in Volume II The volumes are 12x2x12 inches, and elegantly bound in a special steel spring binder This construction has the very important advantage of permitting the manipulation and assembling of the loose-leaf chromophotographs according to the particular interests and requirements of the student The publishers advise that owing to the fact that the photographs are reproduced by the use of the full-tone, gelatine engraving process, the edition is necessarily limited and reprinting impossible.

About 45 pages of Volume I are given to a general introduction to the work as a whole Here the historical development of the problem and method of study are briefly outlined, and the underlying concept of growth is explained as applying equally to mental and to physical phenomena as "end products of a morphogenetic process," and resulting in a "patterned" individual both mentally and physically—this ontogenetic patterning beginning long before birth While "the wealth and complexity of infant behavior are beyond human description" the systematic charting of it is made possible by use of cinematography, which gives a complete and impartial record of patterns or performances as wholes and as integration of components. Furthermore, the use of this method from day to day reveals not only the spatial integration of patterns but also the dynamic integration in time, after the manner of a "moving object taken for the purpose of exhibiting successive phases of motion."

The normative atlas is based wholly on photographic frames of the 16-mm cinema· the naturalistic volume on 35-mm cinema The photographic dome devised and used by the author for the normative studies permits simultaneous photographs in the vertical and horizontal plane, while the observer on the outside can see the subject but cannot be seen from within. The methods and materials used in both the normative and naturalistic studies are described in detail; most of these have been described briefly by the authors in earlier works

The photographs are enlarged from cinematographic frames, and as presented in series vertically on the page they are paralleled by descriptions which point out the more significant details of each picture and the transition in movement from one picture to the next, the time-interval between successive pictures being given in each case. Where photographs are arranged in series horizontally on the page, similar descriptions are conveniently placed for guidance.

In Volume I, 25 different behavior situations are delineated: under posture and locomotion are supine and prone behavior, stair-climbing, sitting, and standing-walking; under perception and prehension are dangling ring and rattle; under perceptual, prehensory, and adaptive behavior are consecutive cubes, massed cubes, tower-building, cup, spoon, cup-spoon, cup-cubes, pellet, pellet-bottle, bell, ring and string, ring-string-bell, paper, crayon, paper-crayon, performance box, form board, ball play, and mirror

In these normative studies depicted in Volume I a high degree of laboratory uniformity and control is attained according to systematized experimental behavior. In the naturalistic studies of Volume II, the behavior of the infant's day has been systematized in terms of his "domestic routine and comparable household conditions" Here are reported all phases of the infant's activity, including posture, locomotion and prehension, and adaptive and social behavior. Also in these studies the records *are codified in terms of basic behavior situations rather than in functional* or psychologic categories such as curiosity, eagerness, insight, sociability, etc.

The belief of the authors is well founded that "any one who is clinically or scientifically interested in the genetic problems of infancy must be prepared to study records of behavior patterns with the same minute interest in structural form which the descriptions of embryology and anatomy demand" Their insistence also that this "ontogenetic patterning of human behavior begins long before birth" is most timely

For human neurology Doctor Gesell, through his work on infant behavior particularly as presented in the Atlas, has opened new possibilities; he has laid the foundation in the behavior of the child for anatomical studies of the brain in correlation herewith As the reviewer has urged elsewhere, it can scarcely be hoped that all particular acts of the individual can ever be explained in anatomical terms Not only is the anatomy too complicated for this in higher animals, but the particular acts are not actually individual entities They are, on the contrary, integral parts of larger patterns and, in the normal organism, inexplicable apart from the total pattern of action On the other hand it is reasonable to hope that the correlation of anatomical and behavioral studies in higher animals and man during the period of rapid individual development will reveal in the anatomy, as this period already has done for lower vertebrates, principles of growth and function which will throw new light on the problem of behavior This outlook is, of course, over a vast and intricate field the resources of which cannot be exhausted by one investigator or group of investigators It is indeed a task *for generations to come Doctor Gesell and his associates deserve the* gratitude of neurologists for providing an exhaustive chronological panorama of behavior of the growing child with which structural studies of the nervous system of known ages can be compared. From this source and method information may be expected that cannot be acquired in any other way concerning behavior in its fundamental relations.

This is a monumental work superbly presented It is especially notable in accomplishment because it deals with a field of inquiry that is rigorously restricted in the application of the experimental method and beset with those difficulties which are allied with the traditional ideas and affects inherent in the subject matter with which it deals. It is a splendid realization of an unusual vision of research in human behavior.

G. E. COGHILL

Fallsington, Pennsylvania

NORMAN L MUNN *An Introduction to Animal Psychology.* New York: Houghton Mifflin Co, 1933. Pp v+439.

This book comprises an intensive study of all the literature dealing with the behavior of the white rat. The author justly refers to it as a companion book to Donaldson's *The Rat.* The purpose of the book, however, is not to amass and systematize the ever increasing body of knowledge on the rat *per se*, but to show in what way those studies elucidate the fundamental principles of behavior. The writer has shown himself familiar with the details of the experiments he reports, and he brings into relief the points of issue and agreement among the writers on particular subjects He reports the experiments and the interpretations of the authors objectively, often in such manner that the student would gain a better understanding of the controversies from their treatment here than from the original polemics of the writers themselves Dr. Munn was not, however, averse to stating his own convictions with respect to the experiments and the theoretical implications of the works which he discusses.

The material covers 670 different references on the white rat. One might feel that the title is misleading since the book deals exclusively with the literature on the white rat, but the emphasis of the material is upon such topics as unlearned behavior, sensory processes, symbolic processes, the learning process, et cetera. Furthermore the bibliography contains a supplementary list of 313 references classified according to the topics discussed. Other animals than the white rat were used as experimental subjects in this additional list of references This is a useful book not only to students of animal psychology but of general psychology as well.

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JOHN J. B. MORGAN *Child Psychology* New York. Farrar & Rinehart, 1934 Pp vii+502

The speed at which work in child psychology has gone forward in recent years is indicated by the fact that the publishers should have considered a revision of Morgan's book advisable after only three years from the time of the first printing In fact the author has covered some 78 references which were not mentioned in the first publication Forty-nine of these have appeared in the literature during the three-year interval between the first and revised editions

While slightly more than a hundred changes occur in the revised edition, these are, for the most part, minor changes of a sentence or paragraph here and there throughout the book. The two major contributions of the revision appear in connection with a discussion of (*a*) the ability of children to generalize and draw inferences as a part of the thinking process, and (*b*) a discussion of the social behavior of childhood.

Although the author contends that the purpose of the revision has been to bring the book up to date, especially with reference to those experiments which have modified or confirmed former theories, he has failed to make these distinctions in the text itself where the revisions occur.

It is my opinion that the original was much too broad in its scope. The purpose was at least twofold, viz to meet the needs in a college text-book and at the same time cater to the demands of an intelligent reading parenthood whose chief concern is with the practical management of children. It is obvious that the rigorous criticism and evaluation of facts and principles which should be embodied in a good college text must be sacrified for the benefit of the other group This dual purpose was undoubtedly a weakness of the first edition which the revision has not improved upon

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THE RÔLE OF DOMINANCE IN THE SOCIAL AND SEXUAL BEHAVIOR OF INFRA-HUMAN PRIMATES: I. OBSERVATIONS AT VILAS PARK ZOO*[1]

From the Department of Psychology of the University of Wisconsin

A. H. MASLOW

I. GENERAL INTRODUCTION

The purpose of this series of papers is to investigate the rôle of dominance in social behavior. This principle of dominance is of fundamental importance in the study of all infra-human primate social relationships and furnishes an obvious and easily investigated nexus between the behavior of the individual and that of the group.

We shall attempt to emphasize the point that has so convincingly been made by Zuckerman (19), namely, that no adequate and valid primate sociology can be elaborated without constant reference to the principle of dominance.

Finally, we shall attempt to show that there are remarkably widespread correlations between various behavior categories that are seemingly discrete and unconnected. Sexual behavior, social behavior, feeding behavior, and aggression behavior will be found to be correlated rather than independently variable types of behavior.

While several approaches to the elucidation of this principle are clearly possible, the stimulus given by Zuckerman's excellent study on infra-human primates has made these animals the most suitable ones for further investigation. In this work (19), is presented for the first time a clear indication of the importance of the dominance principle in primate sociology. Here also we find a preliminary mapping of the relationships holding between dominance and social and sexual behavior in these animals.[2]

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*Recommended by Gardner Murphy, accepted for publication by Carl Murchison of the Editorial Board, and received in the Editorial Office, December 5, 1935.

[1] *I wish to indicate here my thanks to Dr. H. F. Harlow for his very generous help in the determination of the form of this paper.*

[2] See however (19) page 309, where Zuckerman reaches the conclusions

While Zuckerman was the first to attack the problem of dominance in a systematic fashion, a number of other studies may also be found to be useful in this connection These include the studies on the sexual life of infra-human primates by Kempf (9), Hamilton (6), and Bingham (4) Schjelderup-Ebbe (15) has also published some interesting observations on "pecking order" in hens, which may be interpreted as observations on dominance behavior.[8] Carpenter's (5) field study of the social relations of the howler monkey is particularly interesting These papers will be discussed more fully in later papers in this series

Dominance Relationships in Monkeys. Zuckerman (19, p. 224) has given us the best available description of the behavior of dominant and subordinate animals. He says.

> Every ape or monkey enjoys a position within a social group which is determined by the interrelation of its own dominant characteristics and those of its fellows The degree of its dominance determines how far its bodily appetites will be satisfied. Dominance determines the number of females that a male may possess, and except on occasions when there is a superfluity of food, it also determines the amount of food a monkey eats . Their dominance relationships , are conspicuous because they characterize every field of behavior

Dominance relationships, he goes on to say, prevail also among the members of a family, they extend to material objects (such as gloves, toys, and sticks); to punishment relationships, since monkeys

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that "social behavior—the inter-relations of individuals within a group—is determined by the mechanisms of reproductive physiology" This and many similar statements indicate that Zuckerman has missed the full significance of dominance as a determiner of social behavior.

[8] Yerkes' 1925 statement (17, p. 155) is worth quoting in full. "Dominance and subordination are evident in every group of primates Apparently there is no such thing as equality of status and opportunity Leadership, control, mastery are manifest. So in their relations with persons, the monkeys and apes merely exhibit their natural aptitudes and types of social behavior Ordinarily there is aggressive leadership in cage, colony or family group Domination may be by either sex, but dominance must be, and instead of a single leader associated with individuals of relative equality, there is likely to be serial subordination So that each individual secures in its social group the degree of opportunity for control and self-expression to which its characteristics and stage of development entitle it"

See also Murchison's recent interesting papers on the mathematical analysis of a closed social system in chickens usually hand down the punishment they receive; to desired privileges that are handed down by human beings (as petting, tickling, playing), to the determination of the frequency of sexual activity, to all the modes of behavior which have been called by Kempf (9) "prostitution behavior"; dominance relationships determine the fighting behavior of monkeys and baboons.

Thus Zuckerman describes the dominant animal as the one who gets the most females, gets the most food, acquires possession of any desirable material objects, who punishes other animals, who comes forward to be petted or played with, and who calls out "prostitution behavior" in other animals

He describes the behavior of the subordinate animal as being typically the converse of the behavior of the dominant. Thus the subordinate animals get little or none of a limited food supply, and, if they are males, they do not achieve the normal sexual gratification available to the dominant male who "owns" his females. Common to all subordinate animals, says Zuckerman, are the "prostitution responses" consisting of the assumption of the female sexual position in a situation that is not inherently of sexual import.

These descriptions combined with our own researches give us a basis for clearly formulated though cautious definitions of our fundamental terms *We shall define the dominant animal as one whose behavior patterns (sexual, feeding, aggressive, and social) are carried out without deference to the behavior patterns of his associates. The subordinate animal is one whose behavior patterns (sexual, feeding, aggressive, and social) are suggested, modified, limited, or inhibited by the behavior patterns of its more dominant associates.*

It may be noted that our terminology of dominance-subordination differs from the common terminology of ascendence-submission, used by Allport (2), Zuckerman (19), Harlow (7), and others We believe the term "subordinate" to be superior to "submissive" for the following reasons:

1 The less dominant animal sometimes does not occupy his secondary position with any evidence of willingness or *submission*, but is forced to assume this attitude by the violence of his superiors. The dominance drive of the less dominant monkey is not lost but is merely submerged or overshadowed or expresses itself through other channels, and will continue to assert itself whenever the opportunity

arises. In other words, the drive for dominance is continuous, and the mere fact that the more dominant animal attains permanent or temporary superiority does not imply submission by the less dominant animal. Such an implication would be as inaccurate as saying that a horse who had lost a hard-fought race had "submitted" to the winner.

2. The terms ascendance-submission trace back at least as far as McDougall's theory of social instincts. McDougall in explaining this principle suggested that there were two antithetical instincts and, as long as these terms are used, it is difficult to free oneself entirely from this prejudice. It seems to the writer to be more probable that *dominance is a single drive* that is present in all animals and that dominance and subordination are merely two degrees (or perhaps aspects) of a common impulse. The subordinate animal is merely one whose dominance has been overshadowed by greater dominance, and it is important that the terminology used imply this basic fact

II INTRODUCTION

The following observations on the rôle of dominance in the social and sexual behavior of monkeys were carried out at the Vilas Park Zoo at Madison, Wisconsin. The purpose of this study was to obtain a description of dominance and subordination behavior in infrahuman primates of varying species and to obtain evidence as to the relations of food, sex, aggression, and dominance attitude.

III. ANIMALS, HOUSING, AND CARE

Subjects The animals used in this experiment were the series of infra-human primates housed in the monkey building at the Vilas Park Zoo at Madison, Wisconsin In this colony, there were at any one time approximately 25 animals, housed in 13 cages. Deaths, acquisitions, and transfers made this a constantly but slowly shifting population. The larger proportion of the animals dealt with, however, were residents throughout the period of observation. Altogether, observations were made on about 35 infra-human primates of all kinds, ranging from Platyrrhine monkeys to chimpanzees[4] Our animals ranged in age from new-born babies to senile animals

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[4] We have not used the data for the pair of chimpanzees and the pair of cebus monkeys, since there are clear indications that dominance-subordina-

TABLE 1

LIST OF GROUPS STUDIED

Group 1	Sooty mangabey, female, adult
	Mona guenon, adult male.
	Moustached guenon, prepubescent male
Group 2	Four Java monkeys, all male prepubescents
Group 3	Two cebus capucinus, both adult males
Group 4.	Four Java monkeys, three male, one female, all prepubescent.
Group 5.	Three pigtail monkeys, two male, one female, all prepubescent
Group 6	Four macacus rhesus, three pubescent males, one prepubescent female
Group 7.	Two chimpanzees, male (three and one-half years old); female (three years old)
Group 8	Three macacus rhesus, one male, two females, all post-pubescent
Group 9	Three mandrills, one senile male, one prepubescent male, one prepubescent female
Group 10	Four pigtails, two males, two females, all prepubescent
Group 11.	Mona guenon, adult male
	Pigtail monkey, female pubescent
	Coati mundi, adult male
Group 12	Sooty mangabey, adult female.
	Celebes macaque, adult male
Group 13.	Two Hamadryas baboons, adult male and female
Group 14.	Isolated yellow baboon, adult male
Group 15	Isolated white-handed gibbon, adult male.

Table 1 contains a list of the groups of animals used in this study. It should be kept in mind that these groups, in some instances, were not constant. This was true, particularly, for the groups of Java monkeys and pigtail monkeys. Practically all the other groups remained constant throughout the experiment. Much was learned from the isolated animals also. Their relations to the animals in neighboring cages and also to humans were instructive enough to warrant their inclusion in the list of animals used.

Housing and Care. The larger animals at Vilas Park were housed singly and the smaller ones in groups of from two to four in iron-barred cages 84 inches high, 72 inches wide, and either 72 or 144 inches long, one of these two longer cages being occupied by the white-handed gibbon, and the other by the pair of chimpanzees. Each cage communicated through an alleyway at its top with an outdoor cage of approximately the same size. These outdoor cages were used when weather permitted

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tion in these animals is not the same as it is in the Catarrhine monkeys See Carpenter (5), Maslow (11)

The animals were cared for by the attendants at the park The cages were cleaned each morning at 8·30, and the animals were fed twice a day, at 9:00 A.M and at 2 00 P M., on the usual diet of fixed amounts of bread, carrot, apple, banana, and a few lettuce or cabbage leaves. The morning meal was very light. Water was available at all times

IV METHODS AND TESTS

Observations The observations extended over a period of a year and a quarter from February, 1932 through May, 1933, with a gap of one month during the summer of 1932. Records were taken whenever relevant behavior occurred and were written on the spot Only that behavior was recorded that was interesting from the point of view of correlations between dominance and social and sexual behavior.

Observations were made between the hours of eleven and one, three days a week. The length of observation at a single cage varied from about five minutes, for very stable groups in which behavior varied little from day to day, to an hour or more, for groups or pairs that exhibited atypical behavior. When the tests were being made, the experimenter travelled from cage to cage in order At other times, he sat at a point where all the cages could be watched at the same time and records made as relevant behavior occurred in one cage or another

Tests of Dominance An experienced observer needs no objective test to determine the mere fact of dominance within a monkey group. This may be done by simple inspection, since the dominant animal is easily detected by his cocky, aggressive, and confident air. He struts whereas the subordinate animal slinks He stares fixedly and ferociously at the other animals; they avoid his gaze He comes to the front of the cage when favors are being handed out, the subordinate animals retire discreetly to the rear of the cage. He is generally the initiator of group action; the subordinate animal is the follower Whenever dominance is fairly marked, these characteristics make its diagnosis very easy

Simple observation may be supplemented and extended by the use of a simple test, that of throwing small bits of food singly into any cage Since a dominant animal preempts all or most of a limited food supply if hungry (in our experiments the observations were carried out about three hours after the morning meal and the monkeys were almost always eager for food), this affords a ready objective check on other observations

If one animal in the group gets practically all the bits of food thrown into the cage, his dominance is obvious If a substantial percentage of the food bits is secured by more than one animal, diagnosis is less certain, although usually the degree of dominance is closely related to the amount of food obtained by each animal Where dominance is very weak, the subordinate animals become progressively more daring and the food dominance may be partially obscured by other motivational factors

Gradations of dominance may also be measured by a variation of the above test Instead of dropping the food bits midway between two monkeys, the food may be placed closer to one than another When dominance is slight, the subordinate animal will get progressively more food as it is brought relatively nearer to him and farther away from his more dominant partner. This method, therefore, affords a quantitative method of measuring dominance In actual practice, its usefulness was limited by the fact that, in most cases, save where the difference in dominance was slight, when the food was dropped into the cage, the subordinate animal fled precipitately to a far corner of the cage and actually avoided the food even when the experimenter dropped it as close to him as possible Of course, individual differences in hunger drive and appetite for the particular food used are uncontrolled variables in this test. Fortunately, however, they are usually completely nullified by the prepotent dominance behavior

The following technique was also found to be useful in certain cases of dominance that was not very definite In those cases in which several animals came to the front of the cage for food (thus indicating that dominance was not complete in the dominant animal or that there were large appetite differences), bits of food were given to all the animals at the front of the cage, even to those who were carefully avoiding the dominant overlord In many cases this was enough to stimulate the latter animal to assert his dominance at once by driving away all the others When he did not immediately do this, he was further teased by the experimenter's dangling the food bits just beyond his reach and then handing them directly to a subordinate animal. With several repetitions of this procedure, the dominant animal almost always became very angry, viciously attacking the subordinate animals and driving them away. The number of repetitions of this procedure necessary to call forth his angry attack could be considered an inverse measure of dominance. We shall hereafter refer to this procedure as the "teasing" technique.

Social Behavior of Caged Animals It is possible to criticize experiments such as the following on the grounds that the behavior of the caged animals differs from the "normal." Although this is obviously true, such criticisms need not be taken too seriously, since, so far as we know, the behavior of the caged animals differs in no *fundamental* way from that of animals in a "normal" or wild environment. The behavior of the animals at the zoo or in the laboratory is not abnormal or perverted What we have in the laboratory or at the zoo is, essentially, not so much the introduction of new factors as the exclusion of many variable and uncontrollable factors that are operative in large areas or in the wild In any case, however, we shall consider that our results hold only for our conditions until they are proven to be more widely applicable

The laboratory situation is, moreover, an effective way of concentrating temporally and spatially the behavior of the subordinate animal.

V. RESULTS

Limitations of space make it impossible to present all of the data accumulated during the course of the observations We shall instead present them in summarized form according to topic The data on sexual behavior seem interesting enough to warrant separate consideration in a later paper (12) and we shall include here only those observations that are strictly relevant to the thesis in hand.

1. *The Behavior Typical of Dominance and Subordination* The typically dominant animal gets all or most of the food bits thrown into his cage. The subordinate animal gets few or none. In complete dominance, the subordinate animal will flee to a far corner of the cage when food is thrown in. If dominance is less complete, the dominant animal will have to drive the other animals away, and the amount of force necessary to do this will vary inversely with his dominance.

a. The sexual behavior of the dominant animal will almost always be masculine (except under certain conditions which will be discussed later), *and this masculinity of behavior is independent of the sex (gender) of the dominant animal* A dominant female will mount in the masculine fashion other animals in her cage, both male and female. The (typical) sexual behavior of the subordinate animal is female sexual behavior, *again regardless of gender.* Subordinate males will assume the female sexual position as often as subordinate females under similar circumstances. The dominant animal, on the other hand, whether male or female, will rarely assume the female sexual position, except if the dominant animal be a female in heat.

b The dominant animal will have the run of the cage The behavior of the other animals will be oriented with respect to him He will come and go as he pleases and they will get out of his way as he approaches. The subordinate animals in the typical group will usually be bunched as far away from the dominant animal as they can get. Various degrees of apprehension, fear, or actual terror will be displayed by these animals, varying with the degree and the kind of dominance displayed by the dominant animal Any display of dominance by one of the relatively subordinate animals in the group against a still more subordinate animal is characterized by continual apprehensive looking at the dominant overlord of the cage. This display will cease if the latter approaches or stares severely at the less dominant animal Any attacks or fights that may occur are usually initiated or caused by the dominant animal The responses of the subordinate animal to aggressive display will vary with degree of subordination He may fight back, he may assume a passive attitude, he may flee, or, in extreme subordination, he may lapse into a cataleptic rigidity, a waxy flexibility, or become completely limp

2. *Dominance in the Female* The female may be dominant and, when she is, will behave exactly as does the dominant male No differences have been observed in male and female dominance behavior

(The sooty mangabey in Group 1 and the two females in Group 8 were dominant in their groups In Groups 5, 6, 9, and 10, a female was dominant over other animals in the cage, although they were at the same time dominated themselves by the overlord animal of the group. The female sooty mangabey in Group 12 was beginning to assume dominance over her mate when the observations came to an end.)

3 *Dominance and the Oestrous Cycle.* We have some (doubtful) evidence to indicate that a dominant female, when she is forced to assume the female position through the heightening of the sexual drive, will lose her dominance.[5] In other words, the dominance syndrome seems to change as a whole and not in parts. In the two cases observed, the assumption of the subordinate rôle in the sexual act was accompanied by the assumption of the subordinate rôle in the food dominance test, and in aggression behavior This effect may possibly also be attributed to factors other than sexual, e.g., general malaise

(In Group 8, after the early removal of a male overlord, female A was found to be completely dominant to both female B and the remaining male The male was also dominated by female B. The behavior of all three animals was typical and needs no further description. Female A remained dominant until she came into heat. At the next observation period she was found to be completely subordinate to the male who mounted her continually, bullied and bit her, and allowed her to get no food. Her behavior attitudes were completely transformed. She had changed from a bullying, cocky, aggressive, and swaggering animal to a slinking, timid coward who showed terror whenever the male stared at her.

Female B now assumed the overlordship of the group, with the male second and the original overlord last. The new overlord behaved typically, until the time when she also came into heat. The phenomenon previously observed, of loss of dominance upon assumption of the female rôle, was repeated The male became the overlord of the group, with female A second, and the erstwhile overlord last. The status of the group remained thus until the observations had to be cut short.)

These interesting happenings must be interpreted very cautiously and it is not the writer's intent to emphasize them

4. *Age and Dominance.* The behavior syndromes characteristic of

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[5] This may possibly be a sudden accession of dominance in the male, brought on by new and potent stimuli, rather than loss of dominance in the female as a direct result of her physiological condition

dominance and subordination seem to be less exactly marked in young animals There is more blurring of the correlations between dominance and other forms of behavior, ordinarily very closely correlated with dominance. The subordinate animal will be seen to mount the dominant animal at times, the dominant animal will be seen to present more often

(This was found to be true for both groups of pigtail monkeys in this study and for other young animals studied later)

5. *The Incidence of Dominance.* In all of the groups studied here, with the possible exception of one, and in all other groups studied subsequently, there was found to be a hierarchy of dominance, and one animal was always found to be overlord of the group. The one possible exception is Group 3, a pair of cebus monkeys, who were so timid that the test could not be used.

6. *Dominance and Play* It was observed in several groups that the ordinary hierarchy of dominance obtaining in these groups was temporarily abrogated during periods of rather intense play At such times subordinate animals mounted dominant ones and dominant ones presented to subordinate ones No fear or timidity was observed in any of the animals during such periods nor was there any attempt on the part of the dominant animals to assert their dominance until the play period had come to an end and the normal social relationships of the group were resumed This phenomenon was noted only in younger animals, and was never seen to occur in any of the older groups. In these latter groups, for that matter, almost no play at all was ever observed

(In Group 10, one such abrogation of dominance was observed. At its height, it looked much like a group sexual orgy All the animals were seen to present frequently and indiscriminately to any animal that happened to be nearby Mounting always followed but it was merely nominal in the sense that it lasted for but a few seconds and was frequently followed by a reversal in rôle, the presenting animal now mounting This procedure was repeated by all the animals for several minutes with much playful vocalization

In Group 5, when the female was gone and only two males were left, the dominant animal was seen once to indulge in a similar kind of sexual play He had very rarely allowed mounting by the subordinate animal but, in this instance, he began the game of presenting to the subordinate animal and then not allowing him to mount, either turning away or wrestling with his partner as soon as mounting was attempted. The subordinate animal was finally allowed to mount once or twice after this procedure had gone on for some time. This type of behavior was also seen four times in Group 6.)

7. *The Assumption of Dominance Rôle by a New Member of the Group.* A new member of a group usually took his position within the group at once and, ordinarily, this was done without any display of force. An animal that later turned out to be subordinate was subordinate at the very first moment, after the excitement incident to transfer had died down. A dominant animal seemed to become dominant at once and this could be seen in the immediate assumption of what might be called the dominance strut. The other animals in such cases behaved as if they tacitly acknowledged the dominance of this new member In only one case was there any struggle when a new animal was introduced into Group 2. This new animal, we now know, after long experience with him, has an extremely strong urge to dominance in spite of the fact that he is a small animal. He behaved in a dominant fashion when he entered the cage and remained so for a few minutes. But the overlord of the group, after a short interval, got to work and gradually beat the newcomer into a lesser rôle. This process took weeks of continual wrestling and fighting This newcomer is to this day an extremely aggressive animal and in the several groups in which he has been since, has always had to be beaten into subordination, except in one case where he won dominance.

8. *"Prostitution" Behavior.* This concept (that is too susceptible to misinterpretation by inexperienced observers) was first used by Kempf (9) to describe sexual behavior that occurs in inherently nonsexual situations, usually to obtain some "economic" advantages, e.g., food, protection, immunity from attack Such behavior usually consists in the assumption of the female sexual position by an animal that is being attacked, that wants to call forth an attack on a third animal, or that is being prevented from obtaining food, etc. It will be seen from our previous discussion that such an animal would usually be a subordinate one

Such behavior undoubtedly does occur and we have numerous instances of it in our animals Our interpretation of it would, naturally, be very different from that of Kempf and would resemble rather Zuckerman's interpretation We should consider the act of presentation as a symbol of subordination (with some exceptions) and interpret it as a means whereby a subordinate animal indicates to the dominant animal that no challenge to dominance is offered. In situations where such behavior occurs, there is usually an implicit challenge to the dominance of the overlord Such a situation usually calls forth assertion of dominance by the overlord and it is to ward off this threat that the subordinate animal will present. Of course, in this way, the subordinate animal will usually get what he wants, *but he does not get it by offering sexual favors,* as Kempf avers; he gets it rather by admitting social inferiority. In a good many cases, mounting does not take place and yet the dominant animal seems to be satisfied. Presentation must then frequently be interpreted as a social or subordination response, and not directly as a sexual response A few examples will be sufficient to indicate this point

A pan of food is thrown to the cage floor, enough for all. In many cases, the dominant overlord will threaten all the other animals as he gathers the food into his mouth and cheek pouches with both hands and both feet. The other animals will approach hesitantly, *half presenting all the time,* and in this way will reach the food and be allowed to partake. Any direct attack on the food by these subordinate animals would be likely to call forth the resentment of the overlord.

(In Group 8, after female A had lost her dominance, she gradually regained it. And it was during this period of resumption of dominance that she showed the following behavior As the experimenter came to the cage bars, she always approached at the same time that the male did. She would be allowed to eat food that was handed to her directly. After a few repetitions of the teasing technique, he began to show dominance by staring at her or growling. She responded, usually by presenting to him in a purely nominal fashion, i.e., she would accept food but at the same time her hindquarters would be turned in his direction In this position, she could continue to accept food if he were also given some. Her acceptance of food seemed no longer to constitute a challenge to his dominance, and he did not attack her

The female mandrill in Group 9, an animal with a strong dominance drive, whenever she approached the old overlord, exhibited this same behavior of nominal presentation The typical subordinate animal avoids the dominant animal fairly consistently but the female mandrill achieved a much greater freedom of action by this simple device of admitting subordination and thus warding off his dominance attacks. When she neglected this ceremony, she was frequently attacked or threatened The old mandrill was never seen to mount the young female but he seemed nevertheless to be placated by the presenting behavior)

9. *Permanence of Dominance Status.* The dominance hierarchy, once determined, continues unchanged unless other definite factors intervene. When the infrequent changes in dominance status do occur, it is usually possible to assign the cause for this change, which is often some change in the physiological status of the dominant animal, such as that occasioned by illness, accident, or change in oestrus cycle.

We have already spoken of the changes in dominance occurring in Group 8 when this change seemed to be correlated with change in phase of the oestrus cycle.

Change was also observed in Group 12 Toward the end of the observations, the sooty mangabey developed the habit of hanging and whirling on the chain that hung from the middle of the cage roof Since this had a heavy wooden block attached to its lower end, it frequently struck the dominant male, who usually sat on the floor After a good many futile attempts (she was a much faster animal), he gave up his efforts to catch and punish her and, instead, retired to a corner or to the alleyway as soon as she started whirling the chain Still later, his retirement began to be accompanied by squeals of fear, and it seemed obvious that the mangabey was now doing what she did with deliberate intent to annoy. About one month after this behavior had first begun, she seemed to become less and less subordinate and he less and less dominant. She began to get more food and was attacked less often. Finally, on two days just before the end of observations, she was seen so to maneuver herself as to get into a semi-mounting position. Whenever he lay down or sat on the floor, she seized the opportunity to stand astride his body or to stand over him This behavior had never been seen before Soon after, observations ceased and we have no record of subsequent developments

10 *Size and Dominance* While we are not yet in a position to hazard guesses as to the factors determining dominance, we have some data on the influence of at least one of these factors, namely the size of the animals concerned

It is fairly certain that marked differences in the size of a pair of animals will eventuate in the assumption of dominance by the larger animal. In every case where an animal was considerably larger than his partner or partners, he became the absolute overlord

(Groups 1, 7, 9, 13, and also Group 8 at the beginning of observations, when an old male was a member of the group Also, this same phenomenon has been observed in so many groups, since, that there is little doubt about the generality of this factor.)

When, however, the difference in size is not great, dominance may be determined, at least partially, by other factors It is possible, then, that a somewhat smaller animal becomes the dominant animal. Superficially, it seems that such factors as confidence, cockiness, aggressiveness, greater strength of hunger and sex drives, and greater speed of reaction may overbalance a small difference in size We cannot, unfortunately, give any exact data on these differences in size and it was impossible for us to weigh the animals (In Groups 5, 6, and 11, a smaller dominated a larger animal)

VI SUMMARY OF CONCLUSIONS

1 We need feel no hesitation about concluding that dominance is an extremely important determiner of social and sexual behavior in the monkey To this extent, our observations constitute a confirmation of those made by Zuckerman. We may say with him that the animal's status in the dominance hierarchy determines to a very large extent the satisfaction of his bodily needs Or, to express it in another way, we may say that there seems to be a high positive correlation between dominance and other types of behavior, especially feeding, sexual, and aggression behavior We think, however, that Zuckerman has at times grossly underestimated the importance of the rôle of dominance in social behavior.

2 We found that the behavior syndrome characteristic of the dominant animal is as follows. he preempts all or most of a limited food supply, he displays practically all the aggressive behavior seen in his group, he plays the masculine rôle in sexual behavior, *regard-*

less of gender (a dominant animal whether male or female will mount the subordinate animal), he himself is rarely or never mounted; and generally he expresses his drives in behavior without deference to those same drives in his subordinate partners

3 The behavior syndrome characteristic of the subordinate animal is as follows: he gets little or none of a limited food supply; he responds to aggression by passivity, flight, and less often by fighting back; he rarely exhibits any aggressive behavior; he plays the female rôle in mounting behavior, whether male or female; and generally behaves with deference to the drives of his more dominant partner.

4. The female may be dominant over other females or over males, and, when she is dominant, her behavior differs in no observable way from that of the dominant male unless she comes into heat.

5 Some evidence is presented that seems to indicate that the assumption of the female rôle by a dominant female (due to coming into heat) leads to loss of dominance

6. Dominance seems to be less marked in young than in older monkeys.

7. A dominant animal was found in every group studied (with the possible exception of one)

8. The dominance hierarchy may be temporarily abrogated during periods of intense play

9. A new animal introduced into a group will assume his status in the dominance hierarchy of the group in a very short time.

10. The behavior called "prostitution" behavior by Kempf seems to be better interpreted as behavior motivated by the dominance drive, and is thus best thought of as subordination behavior rather than sexual behavior

11. While dominance status is usually fairly permanent, it was observed to change in a few cases for assignable causes.

12. In a group or pair, the largest animal will almost certainly assume the rôle of dominant overlord, if he is much larger than the other animals. If, however, the difference in size is not very great, smaller animals may become dominant.

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THE RÔLE OF DOMINANCE IN THE SOCIAL AND SEXUAL BEHAVIOR OF INFRA-HUMAN PRIMATES: II. AN EXPERIMENTAL DETERMINATION OF THE BEHAVIOR SYNDROME OF DOMINANCE*[1]

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I. INTRODUCTION

The purpose of this paper is twofold, namely, (1) to determine the behavior syndromes characteristic of dominant and subordinate monkeys under experimental conditions, and (2) to determine if possible the fundamental mechanisms and conditions underlying these behavior categories by the systematic control of as many variables as possible

The Animals; Their Housing and Care This experiment was carried out at the Primate Laboratory of the University of Wisconsin during the year 1933-1934 with 20 monkeys as subjects Their names, classification, sex, weight, and approximate ages are found in Table 1.

These animals were housed in single living cages (30" x 30" x 33"), lined along the opposite sides of a long room The cages were of wood construction, except for the front wall, which was made of three-eighths-inch iron bars, centered two inches apart.

The animals were fed once a day, immediately after the experimental period, on fixed amounts of bread, carrots, lettuce, milk, and cod liver oil.

II APPARATUS AND PROCEDURE

Controls. The 20 animals were used in 12 pairings, four subjects

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TABLE 1
PHYSICAL DATA, NAMES, AND CLASSIFICATIONS OF ANIMALS

Familiar name	Classification	Sex	Age	Weight
Pal	Macacus nemestrinus	Male	Pubescent	12 lb 8 oz.
Psyche	" "	"	"	11 " 11 "
Icky	" "	"	"	11 " 8 "
Percy	" "	"	"	11 " 8 "
Growler	" "	Female	"	10 " 6 "
Sappho	" "	"	Prepubescent	10 " 0 "
Nira	" rhesus	Male	"	4 " 2 "
Cwa	" "	Female	"	5 " 5 "
Jack	" "	Male	(Approx 1 yr.)	2 " 0 "
Jill	" "	Male	"	1 " 14 "
Glenny	" mordax	"	Pubescent	6 " 14 "
Spitter	" "	"	"	6 " 9 "
Java	" "	"	"	6 " 11 "
Greeny	Cercopithecus sabaeus	"	Prepubescent	4 " 7 "
Tim	" "	"	"	5 " 8 "
Twit	Cebus capucinus	"	Pubescent	5 " 5 "
Toughie	Macacus rhesus	"	Prepubescent	3 " 15 "
Roughie	" "	"	"	4 " 3 "
Min	" "	Female	"	4 " 6 "
Bim	" "	"	"	4 " 7 "

being used in two pairings. In order to get at the conditions underlying dominance, the controls were so designed as to bring into *especial focus those factors that had as yet received little or no consideration* in the literature.

The animals in the pairings were equated as well as was possible for weight (to avoid the influence of great difference in size), sex, age, and species With certain exceptions to be described later, they were studied in pairs to avoid the obscuring and complicating of the fundamental mechanisms of dominance by large groups of animals Certain behavior will emerge when animals are paired that can not be detected in a larger grouping (and vice versa). The experimental chamber was made large enough for the free behavior of two animals, but was so restricted in size that it concentrated spatially and temporally the behavior of the subordinate animal. Both hunger and appetite were controlled, hunger as has been described above, and appetite by using as an experimental food bits of apple, highly desirable, which the animals were fed at no other time (13) Only those animals were paired that had never before been together or had been separated for at least two months before the experiment, and the animals were isolated in single living cages at all times except during the experimental periods. In this way we were sure to obtain a complete record of *all* the social behavior occurring in a pair of animals from their very first meeting in this experiment.

Scoring Sheets Scoring sheets were used to record, objectively, all significant behavior during the experimental period The following items of behavior were listed and scored. (1) feeding, (2) genital inspection, (3) presentation, (4) dorso-ventral mounting, (5) ventro-ventral copulatory behavior, (6) attempts to mount, (7) bullying, (8) cringing, (9) passivity under aggression, (10) avoidance-escape or flight, (11) initiation of fighting, (12) anger (attack), (13) initiation of play, (14) grooming, (15) self-grooming, (16) general activity (exploration-curiosity), and (17) quiet sitting. Exact behavior definitions of these terms are included below. The data on grooming were gathered both because of possible relation to dominance and also because we considered this to be a good opportunity to attempt possible clarification of some of the questions raised by Dr Yerkes in his interesting paper (20) on this behavior.

Each scoring sheet was divided into 20 parts, one for each minute of the experimental period. These sections were further subdivided into 15-second periods by light lines A stop watch was started at the moment of the beginning of the experimental period and was kept running throughout, allowing continuous timing of all behavior. Duration of behavior was recorded by a continuous line which indicated when the behavior began and when it ended, with a margin of error of less than five seconds. A symbol above this line indicated which animal initiated the behavior Notes were also made on the few bits of behavior not covered by our behavior rubrics, and also to call attention to particularly noteworthy or interesting behavior.

The maximum number of experimental periods for any pair of animals was 30. The actual number of periods for each pair was determined by its stability of behavior. When it seemed that no more could be learned from further experimentation, the experiment was concluded for that particular pairing.

The pairs of animals were evenly divided between the senior and junior author, each being completely responsible for his own pairs. In order to insure complete reliability of recording, all terms were carefully defined on an objective behavioral basis after mutual consultation and were then committed to memory. The first three experimental periods for each pair of animals were recorded by both experimentors sitting at independent tables The resulting scoring sheets showed no significant differences, and indicated excellent reliability of scoring The senior author is responsible for the form of this paper and the conclusions presented in it.

Definition of terms used in recording sheet.

1 *Food*—indicates the kind of food dropped into cage, when each piece was dropped, and which animal got it.

2 *Genital inspection* refers to genital inspection of a sexual nature only Inspection may occur incidentally during grooming without having any sexual import Visual, oral, manual, and olfactory inspection are included

3 *Presentation* refers to assumption of the female sexual position. This may vary from a full sexual presentation, such as that displayed by a female in heat, to a barely perceptible and momentary twisting of the animal's hind quarters in the direction of the other animal. Between these two extremes occur all degrees of variation Some degree of experience with monkeys is absolutely necessary before this behavior can be readily recognized and interpreted Such behavior was recorded by us only when it was obvious and unmistakable.

4 *D-V* (Dorso-ventral mounting or "normal" copulation). This behavior varies so much that it is impossible to give an exact description of it The essential component for our recording, however, was the mere mounting of an animal by another, whether or not functionally adequate. Notes indicated whether or not pelvic strokes ensued, or whether penetration took place (as nearly as we could make out) or whether the part mounted was the head, side, or rear. If the mounted animal remained in the sitting position (as often happened) this was also recorded in the notes

5. *V-V* (Ventro-ventral copulation—face to face).

6 *Erection.* Whenever observed in meaningful situations, otherwise not recorded. Not always possible to observe this, so record on sheets is merely indication that it *did* occur at these times, but it may also have occurred at other times. These records will not be included in our charts and discussions for this reason

7. *Attempts.* Attempts to mount for sexual behavior. Experience necessary to recognize this in some cases, although most of the time it is rather obvious. Behavior of other animal recorded in other columns (as anger, fighting, passivity). Also foreshortened mounting, or any unmistakable beginning of mounting.

8. *Bullying-teasing.* Plucking at other animal's fur, poking him roughly, biting, threatening with growls, taking food away from him roughly, pouncing upon him from above and mauling him. These called bullying only when other animal is more or less passive, or attempts to run away or otherwise avoid his aggressor. If persecuted animal protects himself by fighting back, this is recorded under fighting behavior. It may also turn into play behavior.

9. *Cringing.* An indication of extreme submissiveness. Very obvious and consists of curling up in ball with head hidden, sometimes accompanied by vocalizations indicative of extreme fear.

10. *Passive.* Covers all non-fighting reaction to aggression, not specifically included in rubrics. Often takes form of waxy flexibility. Usually less extreme, more or less apathetic acceptance of the aggression.

11. *Avoidance-flight*—may range from precipitate flight to a constant but not marked avoidance, e.g., always being at opposite end of cage, being on shelf when other animal is on floor, and vice versa. Latter type not recorded. Thus, may be a reaction to a sudden aggression or else long-time submission behavior reaction to fairly well-marked dominance of other animal.

12. *Initiation of fighting.* If attacks of aggressor are resisted, fighting behavior ensues. Score indicates aggressor. In a few cases, difficult to distinguish from play or mock fighting. See *Play* for distinguishing characteristics.

13. *Anger* always refers to anger directed toward other animal, never experimenter or environmental objects. May be reaction to attempted mounting by other animal, bullying, etc. Vocalizations, gestures, postures were indicators of anger.

14. *Grooming.* Searching through fur of other animal or through his own fur. Letter indicates animal doing fur picking. Other animal almost always passive and frequently shows waxy flexibility and drowsiness. A passing interest in other animal's fur is often displayed. This is not recorded unless it continues for at least five seconds. Self grooming, mutual

hetero-grooming, and other variations were all observed and recorded

15 *Play* may be distinguished from fighting by presence of tumbling, frequent mock presentation, nipping instead of real biting, no damage ever done to other animal. No vicious growling or squeals of pain as in fighting Very easily distracted by noise, food, etc Many times initiator can not be determined as they seem to begin simultaneously

16 *Exploration-activity* All preoccupation with physical surroundings Also mere moving about, running, walking, nosing, and fingering of objects. Intended as rough measure of general activity

17 *Quiet sitting* This includes resting and watching other animals' behavior while sitting Frequently, however, quiet sitting (in a subordinate animal) is marked by a submissive attitude, e g, staring fixedly at floor, looking hesitantly at other animal out of corner of eyes, a minimum of movements and these very careful and slow when they do occur No sudden, spontaneous movements or changes of position In other words, less mere resting than a generalized, mild fear of the other animal The animal's head, in such cases, is usually bowed over

Apparatus and Procedure Two techniques were used in this experiment. The technique for the first portion of the experiment was as follows Each animal was housed in a cage that was directly opposite the cage of his experimental partner. For the experiment a runway (24" x 20" x 80"), that fitted snugly between the two cage doors was lowered from the ceiling and the two cage doors were opened Thus a continuous experimental observation chamber was formed by the two cages and the runway

After four pairs had been run, this apparatus was changed to a separate experimental chamber (height 60", depth 40", width 35") in an adjoining room. The two animals to be used were led on a chain or ran of their own accord from the living cage into the experimental cage (after 5-15 days' familiarization with the procedure) Before the animals were used, they underwent a period of training or taming which minimized emotional reaction to the experiment

All observing with this technique was done from behind a one-way screen which permitted clear vision to the experimenter and rendered him invisible to the animals

A further change in the procedure was the more exact control of the factor of introduction of food into the dominance situation Twenty food bits (apple) of equal size were automatically dropped into the chamber during each experimental period, beginning with the sixth. A long tin tube, inclined at an angle of 45 degrees, led from behind the one-way screen into the chamber After a warning signal (three clicks), a single sphere of apple was rolled down the tube into the chamber

The following is a list of the pairings in chronological order. The name of the dominant member of the pair comes first The asterisk indicates the animals tested by the first technique.

Pal	with	Psyche*	Spitter	with	Glenny
Icky	"	Twit*	Java	"	Spitter
Growler	"	Sappho*	Nira	"	Greeny
Jill	"	Jack*	Cwa	"	Tim
Nira	"	Cwa	Min	"	Bim
Psyche	"	Percy	Roughie	"	Toughie

III. Results

The results for the 12 pairs of animals are presented in Tables 2-13 This type of table, which we shall henceforth call the ratio chart, is a convenient way of presenting, in a readily assimilable form, such data as we obtained.[2] It is constructed by scoring a plus for the animal who makes the larger score for any particular kind of behavior during any single experimental period. A minus is scored when he makes a smaller score than his partner during a single period. When there are no scores for either animal, the space is left blank Such a table is easily interpreted and is particularly suited to our purposes because it will show at a glance just which kinds of behavior are consistent, how consistent they are, and will also show which kinds of behavior are positively or negatively correlated with dominance. These ratio charts are presented for the dominant animals only, since the same charts may be read for the subordinate animal by substituting a plus for the minus and vice versa.

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[2] Our gross data charts for each pair of animals are not included for reasons of economy of space, and because they are too expensive to publish They are, however, available for interested workers in a Ph D dissertation on file at the library of the University of Wisconsin

TABLE 2

RATIO CHART FOR ICKY AND TWIT
RECORD FOR ICKY

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Food	=	+		+			+	+								+	+	+												
Genital inspection		+	+	+		+	−	−	+	−	+	+																		
Presentation			−	−	−	−		−			−			+																
Dorso-ventral mounting		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+													
Ventro-ventral																														
Attempts to mount		+			+	+	+	+	+	+	+	+	+		+			+												
Bullying	+	+	+	+	+	+	+	+						+	+	+	+	+												
Cringing	−	−	−	−	−		−	−	−	−		−	−	−	−	−	−	−												
Passivity		−	−				−		−	−	−	−	−	−	−	−	−	−												
Avoidance, flight	−	−	−	−		−	−	−	−			−	−	−		−														
Initiation of fighting									+		+	+	+	+		+	+													
Anger attack																														
Initiation of play																														
Grooming			+	+	+		−					−																		
Self-grooming																														
Exploration activity	+	+	+	+	+	+	+	+	=	+	=	+	+	+	=	−	=	=												
Quiet sitting	−	−		−	−	−	=	−	=	−		=	=	=				−												

(+) means a larger score for the dominant animal in that particular kind of behavior for that particular period

(—) means a larger score for the recessive animal.

A blank space indicates that no behavior occurred during that period in either animal.

TABLE 3
Ratio Chart for Jack and Jill
Record for Jill

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Food																—	—	+	+
Genital inspection																			
Presentation	+	+	+	=	+		+	—	—		+		—	—	+	+		+	+
Dorso-ventral mounting	+	+	+	+	+	+	—	+	+	+	+	—	—	+	+	=	+	—	—
Ventro-ventral																			
Attempts to mount	—	+	—	+	—	—	+	+	+	+			—	+	+	=	+	—	
Bullying																			
Cringing																			
Passivity																			
Avoidance, flight	—	—	—	—	—		—	—							—				
Initiation of fighting																			
Anger attack		=	+	+	+	+	+	—	+	—		+	—		—	—			
Initiation of play																		—	
Grooming	—	—	—	—	—	—	—	—	—					—	—	—		+	
Self-grooming																			
Exploration activity	=	—	—	—	—	+	—	=	=	—	—	—	—	—	—	—	—	=	—
Quiet sitting	+	+	+	+	+	+	=		=	+	+	+	+	+	+	+	+		=

TABLE 4

RATIO CHART FOR PAL AND PSYCHE
RECORD FOR PAL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Food		+		+	+		+	+	+	+		+		+	+								+	+	+
Genital inspection			+		+				+			+				=	−								
Presentation			−						=						+			+		+	+	+			
Dorso-ventral mounting	+	+	+	+	+	−	+	+	+	+	+	+	+	+	−	+	+	+	−	−	−	+	−	−	−
Ventro-ventral	−	−	−	−	−	−	−	−	−	−	−		−	−	−	=	−	−	−	−	=	−	−	−	−
Attempts to mount	+	=	=	+	+	+								−		+	−		−	+		+		+	+
Bullying		+	+	+	+		+		+	+	+	+	+	+	+		+	+	+			+	+	+	+
Cringing				−	−					−	−	−	−	−											
Passivity											−	−					−	−					−		
Avoidance, flight		−	−	−	−		−		−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Initiation of fighting	+	+	+	+	+	+	+	+	+	+	+			+	+	+	+	+		+	+	+		+	−
Anger attack			+	+	+			+	+	+														+	+
Initiation of play			+		−																				
Grooming	+	−	=	+	−	−	−	−	=	=			+	−			+					−			
Self-grooming			=		−				−	+															
Exploration activity	=		=		+	+			+	+	+	+	+		+	+	+	+	+	=		+	+	+	+
Quiet sitting	=	−	=		=	−			−	−	−	−	−	−	−	−	−	−	−			−	−	−	−

TABLE 5

Ratio Chart for Growler and Sappho
Record for Growler

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Food														+	+	+	+
Genital inspection		—															
Presentation		—					+	—		—	—						—
Dorso-ventral mounting																	
Ventro-ventral																	
Attempts to mount																	
Bullying																	
Cringing	Sappho cringing continually																
Passivity														—			
Avoidance, flight	—														—	—	—
Initiation of fighting																	
Anger attack	+													+	+		
Initiation of play																	
Grooming	—	—				+	—	—	—	—	—	—	—	—	—	—	—
Self-grooming																	
Exploration activity	+	+	+	+	+	+	=	+	+	—	+	+	+	+	+	=	=
Quiet sitting	—	=	—	—	—	—	—	+	+	+	+	—	—	—	—	—	—

TABLE 6

Ratio Chart for Psyche and Percy
Record for Psyche

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Food						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Genital inspection			−	−				−		−		−			−		+						−	+		+	−	+	+	−
Presentation	−	−	−	−	+		+	+	+	+	+	+	+		+	−	+	+			−	+	−				+	+	−	−
Dorso-ventral mounting	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ventro-ventral									+								+						+							
Attempts to mount	−	−				+	+	+					+	+	+	+	−			=		+	−	+		=	−		−	−
Bullying	+	+				+	+			+	+			+	+	+	+			+		+	+	+	+	+	+	+		
Cringing								−				−																		
Passivity	−	−	−	−	−		−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Avoidance, flight	−	−				−	−	−		−			−	−	−	−			−	−	−	−	−	−	−	−	−	−		−
Initiation of fighting	+	+								+											+	+	+	+	+					+
Anger attack		+				+	+			+		+		−	+	+						+								
Initiation of play		+		+	+								−																	
Grooming	+	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−	+	−	−	−	−	+	+	+	−	+	−	−
Self-grooming																														
Exploration activity	+	=	+	+	+	+	+	=	+	+	−	+	+	−	+	+	+	+	+	=	+	=	+	+	+	+	+	−	=	+
Quiet sitting	−		−	−	−	−	−	−	−	−	−		−	−	−	−	−	−	−		−		−	−	−	−	−	+	=	−

TABLE 7

RATIO CHART FOR NIRA AND GREENY

RECORD FOR NIRA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Food						+	=	−	−	−	−	=	−	−	+	−	−	+	−	−	−	−	−	−	=	+	−	+	−	−
Genital inspection											−	−				+														
Presentation									+																					
Dorso-ventral mounting	+								+							−				+	+									
Ventro-ventral																														
Attempts to mount	+	+	+							+	−		−	=	=				−	+	+	+	+		+	+	=	+	+	+
Bullying		+	+						+	+	+	+		+	+	+			+	+	+	+			+			+	+	+
Cringing				−																									−	
Passivity	−	−	−						−	−	−	−		−	−	+				−	−				−			−	−	
Avoidance, flight		−	−	−						−	−	−	−	−	−			−	−	−	−								−	−
Initiation of fighting		+	+	+						+		+			+	+			+		+	+	+			−	+	−	+	
Anger attack															−				=										+	
Initiation of play	+	+																		+				+	=	+	+	+		
Grooming	+	+	+	+		+	+	+	+	+	+	+	−	+	−	−	−	=	+	+	−	+	−	+	+	−	+	+	+	+
Self-grooming			+	+									+		+		+	+				+	+			+			+	
Exploration activity	+	+	+	+	=	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+
Quiet sitting	−	−	−	−	=	−	−	−	−	−	−	=	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

TABLE 8
RATIO CHART FOR NIRA AND CWA
RECORD FOR NIRA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Food							−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	=	+	+	=	+	+	+
Genital inspection																	+													
Presentation	−	−													−											−	−		−	+
Dorso-ventral	+	+		+	+		+			+	+	+	+	+	+	+	+	+		+	+	+	+	+		+	+	+	+	+
Ventro-ventral																														
Attempts to mount							+				−			+		+		+	+	+	+		=	−	−				+	
Bullying												+										+			+	+	+	+	+	+
Cringing																														
Passivity	−			−	−					−		−	−	−	−	−	−	−		−	−	−	−		−	−	−	−	−	−
Avoidance, escape																	−					−				−	−	−	−	−
Initiation of fighting																							−		+	+			+	+
Anger attack														+									−							−
Grooming	+	+		+	+	+	+	+	+	+	+	−	+	+	±	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Self-grooming	−	−	−	−	−	−	=		−	−	−	−	−	−	−	−	−	−	−	−		−	−	−				−		
Initiation of play																								+	+	+	+		−	
Exploration activity	+	+	+	+	+	+	=	+	+	+	+	+	+	+	+	+	+	+	+	+	=	=	+	=	+	+	+	+	+	+
Quiet sitting	−	−	−	−	+		=	=	−	−	−	−	−	−	−	−	−	−	−	−		=	−		−	−	−	−	−	−

TABLE 9

Ratio Chart for Spitter and Glenn
Record for Spitter

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Food						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Genital inspection		−					−								−															
Presentation									−																					
Dorso-ventral mounting		+			+	+	+	+	+	+	+	+			+	+	+	+	+		+	+	+	+	+		+	+	+	+
Ventro-ventral		−		+	−								+		−				+			+					−			
Attempts to mount	−	−			+	−	+		+						−	−		−	−	−	−				−		−			−
Bullying		+				+	+	+																		+				
Cringing							−																				−			
Passivity		−			−	−	−	−			−	+			−	−	−	−			−	−	−	−	−		−	−	−	−
Avoidance, flight							−		−	−					−	−	−	−	−		−									
Initiation of fighting	−	−	−			+	+		−						+	+		+	+	+	+				+	+				+
Anger attack	+						+											+				+								
Initiation of play							−		−		−				−					−										
Grooming		−	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Self-grooming																		+				+		+	+					
Exploration activity	−	=	+	+	−	−	−	=	+	=	−	−			−	−	−	−	−	−	−	−		−	−			=	−	−
Quiet sitting	+	=	−	−		=	=		−		=	=			−	+		+	+	+	=	=	+		−				−	+

TABLE 10

RATIO CHART FOR SPITTER AND JAVA
RECORD FOR JAVA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Food						+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Genital inspection				—																	
Presentation																					
Dorso-ventral mounting	—																				
Ventro-ventral																					
Attempts to mount																					
Bullying																					
Cringing						—															
Passivity																					
Avoidance, flight						—	—														
Initiation of fighting																					
Anger attack																					
Initiation of play																					
Grooming	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Self-grooming	—		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	=
Exploration activity	—	=	+	+	+	+	+	+	+	—	=		+		—		+	—	+	+	
Quiet sitting	+	—		—		—	—	—		—			—	—	+		=	=	—		

Summary of Results. The data for all our pairs are presented in Table 14 in summarized form. Only those types of behavior are included that seem to have some significance for our main purpose. The data for genital inspection, erection, attempts to mount, anger, self-grooming, and quiet sitting were not included either because of obvious lack of correlation with dominance, or because of paucity of data, or, as in the case of quiet sitting, because we already had an inverse measure of the same behavior Ventro-ventral copulatory behavior was omitted because these data did not lend themselves to statistical treatment, but seemed, instead, to need individual treatment. In spite of the fact that the data on presentation showed little correlation with dominance, they were included because of the importance they have assumed in the literature on the subject of monkey behavior [see Kempf (11) and Zuckerman (21)]. All other categories of behavior that were included in this table are considered to be correlated with dominance to a greater or lesser degree.

The figures listed under food, grooming, and general activity represent not raw data, but the total number of plus signs scored in the ratio charts for each animal Using the raw data would have given us near-astronomical figures to contend with. All the other figures are totals of the raw data for the whole experiment, e.g , the number of times Pal mounted Psyche throughout all their 25 periods together, the number of times Nira bullied Cwa during all their 30 periods together, etc.

The pairings are listed at the top of the table with the name of the dominant animal above the name of the subordinate animal of the pair The same is true for the scores in each box.

A summary of the lumped data for all the animals is presented in Table 15. Each figure represents the total number of times the behavior occurred throughout the experiment for the dominant or the subordinate animal, as the case may be, except for the food-getting activity and grooming, where each figure represents the total number of plus signs obtained in the ratio charts

Certain of the pairs of monkeys, however, may be considered as atypical. In the case of the two inter-species pairs (Nira-Greeny and Cwa-Tim), the green monkeys were more agile and speedy than

TABLE 14

SUMMARY OF DATA

	Pal Psyche	Icky Twit	Growler Sappho	Jill Jack	Nira Cwa	Psyche Percy	Spitter Glenny	Java Spitter	Nira Greeny	Cwa Tim	Min Bim	Roughie Toughie
Food	13	7	4	2	20	25	25	16	5	7	3	6
	0	0	0	2	2	0	0	0	17	14	0	0
Presentation	17	1	3	36	1	21	0	0	1	17	0	0
	6	17	14	22	8	19	1	0	0	0	0	1
Dorso-ventral	140	104	0	190	77	195	61	0	6	24	1	0
mounting	58	0	0	119	8	0	0	1	1	0	0	0
Bullying	121	77	0	0	41	37	7	0	47	43	2	11
	0	0	0	0	1	0	0	0	0	0	0	1
Cringing	0	0	S cring.	0	0	0	0	0	0	0	0	0
	23	61	contin.	0	0	2	2	2	2	0	1	0
Passivity under	10	0	0	not	3	0	1	0	1	1	0	0
aggression	23	81	3	recor.	83	202	44	0	36	52	1	4
Flight, escape	3	0	0	3	1	0	1	0	0	0	0	1
	147	114	9	18	16	69	28	4	33	16	17	9
Initiation of	153	51	7	40	14	14	32	0	37	15	0	3
fighting	6	1	0	25	5	0	16	0	4	1	0	3
Grooming	4	3	1	1	28	8	26	0	21	10	11	6
	7	2	13	12	1	22	3	21	6	1	0	1
Exploration	16	12	13	1	26	22	3	11	13	1	1	1
activity	0	1	1	14	0	3	19	4	16	25	6	6
Initiation of	3	1	0	0	18	4	4	0	24	0	0	0
play	2	0	0	11	8	1	11	0	6	1	0	0

TABLE 15

SUMMARY OF RESULTS OF 12 PAIRS

	Dominant animals	Subordinate animals
Food getting	133	35
Presentation	97	87
D-V mounting	798	187
Bullying	386	2
Cringing	0	93
Passivity under aggression	16	529
Flight	9	580
Initiation of fighting	366	61
Initiation of play	54	40
Activity	117	96
Grooming	119	89

their dominant rhesus partners with the result that the obtained scores on food getting and activity differ from those obtained in intra-species pairings[3]

In two pairs of animals dominance was not complete (Jill-Jack and Pal-Psyche) with the result that the behavior for the members of these pairs is atypical in many of the scored behavior traits.[4]

A more accurate picture of dominance and subordination can be obtained by omitting from the corrected summary the scores made by Nira-Greeny and Cwa-Tim (inter-species pairs) in food getting and activity, which were particularly affected by difference in speed, and by omitting the scores made by Jill-Jack and Pal-Psyche in all the other behavior categories. Thus we shall have data for ten pairs. This corrected summary of results is given in Table 16, and we shall base our discussions of results upon it rather than on the uncorrected data.

This summary, we believe, gives a more typical picture of dominance and subordination behavior than does the uncorrected summary, and henceforth we shall refer to it rather than to the previous summary

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[3] See discussion in first paper (14). The two green monkeys are excellent illustrations of our contention that the drive to dominance is continually active, even in subordinate animals, and will express itself in behavior when external social inhibitions are such that they may be neglected with impunity or else circumvented.

[4] Nira and Cwa showed a change in dominance toward the end of the experiment with Cwa beginning to behave in a dominant fashion We shall not correct for this factor because it is impossible to select any one point at which dominance was reversed.

TABLE 16

CORRECTED SUMMARY OF RESULTS OF TEN PAIRS

	Dominant animals		Subordinate animals	
Food-getting	121	(97%)	4	(3%)
Presentation	44	(43%)	59	(57%)
D-V mounting	468	(98%)	10	(2%)
Bullying	265	(99%)	2	(1%)
Cringing	0	(0%)	70	(100%)
Passivity under aggression	6	(1%)	506	(99%)
Flight	3	(1%)	415	(99%)
Initiation of fighting	173	(85%)	30	(15%)
Initiation of play	51	(65%)	27	(35%)
Activity	103	(65%)	55	(35%)
Grooming	114	(62%)	70	(38%)

IV. DISCUSSION

The types of behavior which are most closely correlated with dominance or subordination and which should, therefore, be included in a description of their behavior syndromes, may now be listed.

For dominance, these are.

1. The ability to preempt all or most of a limited food supply
2. The assumption of the above or masculine position in copulatory behavior, regardless of the sex of either animal
3. The assumption of the bullying rôle
4. The initiation of most of the fights that occur between the pair of animals.
5. The initiation of (roughly) twice as much play as is initiated by the subordinate animal
6. A tendency to greater activity and freer exploration
7. A tendency (perhaps) to groom rather than be groomed.

The types of behavior most closely correlated with subordination are.

1. Cringing.
2. Passivity under aggression and sexual attempts.
3. Flight from aggression or danger of aggression.

If we use these two lists of traits that are correlated with dominance or subordination to construct the behavior syndromes of dominant and subordinate animals, we get the following:

The dominant animal:

1. Preempts all or most of a limited food supply (97%).

2 Assumes the above or masculine position in copulatory behavior (regardless of gender) (98%)
3 Does practically all the bullying (99%) observed in a pair, and is rarely or never bullied by the subordinate animal.
4 Initiates most of the fights (85%) that occur in the cage and is, of course, the victor in practically all of them
5. Initiates (roughly) twice as much play (65%) as his subordinate associate
6 Shows a tendency to greater activity (65%) and freer exploration of his environment than his partner
7. Shows (perhaps) a tendency to groom rather than to be groomed (62%).
8. Is rarely passive under sexual aggression (1%), never cringes and never flees from the subordinate animal

The subordinate animal.

1. Gets little or none of a limited food supply.
2. Always, or nearly always, assumes the below or feminine position in copulatory behavior (regardless of gender), but almost never plays the masculine rôle in such behavior.
3. Is very rarely the aggressor, almost never bullies the dominant animal but is usually bullied.
4 Initiates few of the fights that occur in the cage
5. Responds to bullying or sexual aggression by passivity, cringing, or flight
6. Initiates less play than the dominant animal
7. Shows tendency to be less active and less free in exploration.
8. Shows (perhaps) a tendency to be groomed rather than to groom.

For reasons already discussed, we may discard several types of behavior that have not proved to be valuable in the construction of the behavior syndromes of dominance and subordination. These are (1) genital inspection, (2) presentation, (3) ventro-ventral copulatory behavior, (4) erection, (5) attempts to mount, (6) anger, and (7) quiet sitting. We do not wish to imply that these may not have significance with relation to dominance Indeed we suspect that several of the behavior types are exceedingly interesting from just such a point of view. These data were, however, inadequate for proper evaluation.

We wish to call especial attention to the data on presentation. This behavior has been given high importance by Kempf (11) and Zuckerman (21), the latter regarding it as an important way in which a subordinate animal adjusts himself to a system based on dominance A similar interpretation may be read into Kempf's paper He considers this behavior to be the chief manifestation of "prostitution." The implication that it is a necessary or unique characteristic of subordinate behavior is obviously exaggerated The dominant animal presents almost as often as the subordinate animal and the subordinate animal often fails completely to show this behavior.

It is quite true that in many cases of presentation the only motivation in the presenting animal is a subordinate attempt to adjust to a system of dominance But it is just as true that there are other situations in which this behavior occurs that are not directly dominance situations. The most important of these is play; another is curiosity, another is the attempt to lure an enemy within striking distance.

One form of behavior that we have not included in our table is ventro-ventral copulatory behavior. This behavior may have a very interesting relationship to dominance and will be discussed more fully in the next paper in the series (15).

Our data on grooming are equivocal and conclusions may not be drawn before more data are gathered. The corrected summary shows that the dominant group groomed 53 per cent more than the subordinate group (114 plus scores for ten dominant animals and 70 for ten subordinate animals) Three of the ten subordinate animals, however, groomed more than their dominant partners, and in some cases the dominant animal did not groom at all.

We are inclined to interpret our data as a resultant of two facts First, there are strong individual differences in grooming, some animals being predominantly groomers and others, groomees; second, the dominant animal that is a groomer can force the subordinate animal to be groomed but the dominant animal that is a groomee cannot force his subordinate partner to be a groomer if the latter animal is not so inclined.

The data are particularly interesting in view of Yerkes' recent paper on grooming behavior (19). He presents in this paper the interesting hypothesis that "grooming, as typified by chimpanzee, represents an important pattern of primate social response from which have evolved varied and highly significant kinds of social service" (p 5). Our data show grooming to be an important form of social behavior in the catarrhine monkey, but they do not permit us to call this behavior a kind of social service, if we mean by this phrase altruistic, unselfish behavior in which the motivation is the securing of good or pleasure to another animal. Grooming in catarrhine monkeys may well be a progenitor of social service, an evolutionary fore-runner from which altruism may eventually develop, but in our animals this behavior both in the groomer and the groomee was what we must call "selfish."

No other construction can be put upon the behavior of the dominant animals who forced their partners, willy-nilly, to submit to being groomed. There were also other dominant animals, who generally preferred being groomed to grooming, who persistently presented to the subordinate animals for grooming. Very frequently, when the subordinate animal refused to groom and turned away, he was viciously attacked by the dominant monkey. It would seem then that altruism or social service (at least in grooming) cannot be said to begin until we get to the chimpanzee

While it is extremely difficult to make definite statements about this aspect of grooming behavior without anthropomorphizing, the grooming behavior of our monkeys (while showing more mutuality of participation than any other type of behavior) exhibited less mutuality and more dominance-subordination than is ascribed to the chimpanzee by Yerkes A young pair of chimpanzees observed by us in our previous study (14) also showed far more cooperative and altruistic behavior than we have ever seen in any monkeys or baboons, and it is probable that the differences that exist between chimpanzees and monkeys with respect to grooming are a reflection of this general difference between apes and sub-anthropoid primates

The data that we have, of course, permit no generalizations beyond the catarrhine monkeys The general picture, however, of dominant-subordinate behavior within this group would appear to be clearly defined since all of our work is in substantial agreement with that of Zuckerman on the baboon and with the historical data that he presents.

Carpenter's excellent monograph on the behavior of howler monkeys in the wild (6) clearly shows that these animals have a different kind of dominance-subordination relationships It seems fair to say that dominance and subordination are found in the social relationships of these animals, especially in juveniles, but that they exist in a much more tenuous and diffuse form than is found in the catarrhine monkey.

The differences are due, certainly, to some extent, to the differences in environmental conditions in the wild and in the laboratory Abundance of food makes competition unnecessary for the howler monkey Our data show that when competition for food is made necessary by a limited supply, the struggle for dominance is heightened and made more evident. In at least one of our pairs, dominance status was not clearly established until the factor of competition for food was introduced into the experimental situation Carpenter also says (p. 37), "Were conditions such as to bring about keen competition for food, social facilitation and inhibition of feeding would be more pronounced than it is in the communal groups of howlers."

Generally instances of competition in howler monkeys are rare From Carpenter's description, it would seem that dominance relationships emerge from the play of juvenile animals and are most evident during such play He says (p. 81), "Young howlers apparently compete with each other during playful activity Individuals which show much facility in the playing activity control the course of action to a greater degree than others Viewed objectively, play may function to establish among young animals a dominance scale, similar in kind but far less in degree than the dominance so thoroughly described by Zuckerman for the baboon"

It seems to be at least a possibility that the cebus monkey will also, upon closer study, be found to exhibit dominance-subordination behavior of a non-catarrhine type. The fact that solitary females of this species have been found in the wild indicates this possibility (21).

We are now in a position to bring up for discussion several other more general questions with relation to dominance that should not be overlooked.

1. *When was dominance established?* If we take as our criterion the first emergence of *scorable* dominance behavior, we find that in ten out of our twelve pairs, dominance was established before the fourth period In six pairs, it was established in the very first period, and in one other pair, during the second period Dominance seems, therefore, to be a relatively immediate status into which, most of the time, both animals fall at once. It would be fairly accurate to say that one animal seemed, in most cases, to assume at once that he was

dominant, and that the other animal seemed, just as naturally, to admit that he was subordinate. Attitudes, gestures, and other *non-scorable* dominance behavior in some cases appeared before scorable behavior was observed. A trench-worn sergeant, during the war, described a similar situation when he said, "You go over the top, pick your heinie, look him in the eye, and one of you is a dead man before you start fighting."

Some animals, of course, assumed subordinate status with but ill grace. They seemed to be "naturally" dominant animals and had to be pushed into an inferior rôle by sheer force of arms. This happened in two of our pairs (Java-Spitter and Spitter-Glenny).

2. *What is the nature of dominance?* It is possible to envisage dominance as a drive or motive to behavior If it be a drive it would seem furthermore to be one which is separable from the feeding drive or the sexual drive, although highly correlated with them We are reminded here, very forcefully, of the analogous mechanisms that have been discussed for man. Adler's ego or superiority drive, MacDougall's instinct of self-assertion (and also his instinct of self-abasement, corresponding to subordination), Allport's ascendance and submission, etc. If dominance is a drive, it is very different from others in several important respects that would necessitate an overhauling of the general concept of "drive," e.g., it is continuous and not cyclic, it has two aspects, dominance and subordination, it is not known to be directly a function of simple glandular or physiological mechanism, it expresses itself through many indirect channels such as food, sex, pugnacity, that are themselves direct functions of simple drives.

3. *What factors determine dominance?* Zuckerman suggests, tentatively, size, better canines, and better fighting ability He discards size alone as a determining factor because of the fact that smaller animals are often dominant over larger animals. We also have found this to be true. The other two factors suggested by Zuckerman imply that dominance is always a result of fighting In our animals, this was not found to be the case, although it may be true for the Hamadryas baboon. Any valid explanation would have to take account of the fact that in most cases dominance is established without any physical violence at all

It is just as possible also to envisage dominance as an "attitude," to the determination of which a dominance drive core (physiological in nature) would contribute, but which is also a delicate balance or resultant of the effects of this putative drive, the immediate social situation, the previous experience of the animal, his physiological state of hunger, thirst, etc., the physiological state of the partner animal, etc.

Our suggestion would be that dominance is determined by or actually is a composite of social attitudes, attitudes of aggressiveness, confidence or cockiness that are at times challenged, and which must then, of course, be backed up by physical prowess. A very apparent "sizing-up" process goes on during the first moments of meeting, and it is during these moments and during this process that dominance seems to be established. A later paper will discuss this question more fully.

4. *What rôle does the struggle for food play in the determination of dominance?* In 10 of our 12 pairs and possibly in an eleventh, dominance was established before the struggle for food became a factor in the situation. This is not to say that the introduction of this factor is of no importance. In many of our pairs it seemed to be a sharpening factor, bringing the respective behavior syndromes to a sharp focus. Generally then we must consider our data to be a disproof of the hypothesis advanced by Harlow and Yudin (9) on the basis of their ingenious experiments on social facilitation of feeding.

5. *Is an animal that has been subordinate in one pairing necessarily subordinate in other pairings?* Four of our animals were used in two pairings. Three of these animals, who had been subordinate in the first pairings, were dominant in the second. The other animal was dominant in both pairings.

6. *How permanent is dominance, once established?* In 11 of our 12 pairs, dominance, once established, remained constant throughout the experiment. In one pair, it seemed to be changing in the last periods This finding may be due to the comparatively short extent of the experimentation with any one pair Changes in dominance were observed somewhat more frequently at the Vilas Park Zoo (14), where observations of a group sometimes extended over a period of a year and a half

7. *Is the drive for dominance determined predominantly by innate*

rather than by environmental factors? The previous discussions would seem to indicate a preponderance of hereditary influence in the determination of the dominance drive but we do not feel at all certain of this We feel that the data that we have gathered and those available in the literature are inadequate with respect to this question. It is probable that the question cannot be attacked until our experiments can be repeated with animals that have been born in a laboratory.

8 *Is there a "general" dominance factor or are there specific food dominance, sex dominance, and aggression dominance drives?* We must again plead inadequacy of data in attempting to discuss this question. Our data show in general that there is high correlation between sex, feeding, and aggression behavior, but there are several exceptions to this general finding, indicating that these behavior types are separable, practically as well as logically. The fact that we have not obtained perfect correlations between dominance behavior, feeding behavior, and sexual behavior indicates that they are independent drives that are highly correlated with each other but are far from being identical

9 *Is dominance necessarily a masculine characteristic?* We have already expressed ourselves on this point in our previous paper (14), but we wish to reemphasize the fact that a female animal may be dominant, and that when she is, her behavior will differ in no way from that of a dominant male Cwa, a female, was dominant over Tim, a male, and had begun to assume dominance over Nira, also a male, at the end of the experiment She behaved in the typical dominant fashion

V. SUMMARY AND CONCLUSIONS

Two experimental techniques were used with 12 pairs of monkeys in an effort to achieve a quantitative determination of the behavior syndromes characteristic of dominance and subordination The factors of age, weight, sex, species, introduction of food, and previous experiences were controlled as well as was possible. The animals were scored for almost all known types of social and sexual behavior.

Several of these types of behavior were found either to occur too infrequently or else to be unrelated to dominance and were, therefore, not included in the description of the behavior syndromes of dominance and subordination. These were (1) genital inspection, (2) presentation, (3) erection, (4) attempts to mount, (5) anger, (6) quiet sitting, and (7) ventro-ventral copulatory behavior The sixth was discarded because in "general activity" we had an inverse score of the same behavior. The seventh was discarded, in spite of the fact that it seems to be very significant behavior, because of the paucity of data It is a type of behavior that clearly calls for further investigation.

Other types of behavior were found to be closely related to dominance and subordination, and the following behavior syndromes seem to be characteristic of dominance and subordination.

The dominant animal typically:

1 Preempts all or most of a limited food supply (97%).
2 Frequently mounts the subordinate animal, irregardless of the gender of either the mounting or mounted animal (98%).
3 Is rarely or never thus mounted by the subordinate animal (2%).
4 Frequently bullies the subordinate animal (99%), but
5 Is almost never thus bullied by the subordinate animal (1%)
6 Initiates most of the fighting that occurs in the pair (85%).
7 *Never* cringes under aggression (0%)
8 Is rarely passive under aggression (1%).
9. Almost never flees from the subordinate animal (1%).
10. Is likely to be more active than his subordinate partner (65% of all scores).
11. Is likely to do more grooming than his subordinate partner (?), (62% of all scores)
12. Is likely to initiate more play than his subordinate partner (65% of all scores)

The negative of each of these 12 behavior characteristics gives the behavior syndrome for the subordinate animal.

Dominance may be envisaged either as a drive to behavior or as a social "attitude" If the former, it would then be a unique kind of drive, differing in several fundamental respects from such drives as hunger, thirst, etc. In the laboratory situation that we have canvassed, dominance is very often established at the very first meeting of the pair. Dominance was observable in one member of every pair we studied, although it varied in degree

The factors that seemed to determine dominance in our evenly matched animals seemed to be not so much size, physical strength, etc., as an attitude of aggression or confidence. It was infrequently the outcome of a physical struggle. Neither does it seem to depend very frequently on struggle for food, for, in at least 10 of our 12 pairs, dominance was established before food was introduced into the situation.

Dominance status may change, although this was infrequent in our experimental set-up, being observed in only one of our 12 pairs

An animal subordinate to one animal may be dominant over another.

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THE RÔLE OF DOMINANCE IN THE SOCIAL AND SEXUAL BEHAVIOR OF INFRA-HUMAN PRIMATES. III. A THEORY OF SEXUAL BEHAVIOR OF INFRA-HUMAN PRIMATES*[1]

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The sexual behavior of monkeys seems to the casual observer to proceed on no fixed principles and to have no discernible order whatsoever. Every conceivable kind of sexual behavior may be observed, and even the biological sex differences seem at times to have no meaning, for males act like females and females like males Even this behavior is not consistent, for the same monkey may act like a male with one animal and like a female with another, a few moments later. Aside from these considerations, their sexual behavior is astonishing for its frequency alone. It may be that this confusing profusion of sexual behavior, both in kind and amount, is responsible for the absolutely amazing neglect accorded to the problem of describing and explaining this aspect of the life of infra-human primates This neglect is the more remarkable in view of the fact that such study offers another important approach to the problems of human sexuality.

It is the purpose of this paper (1) to give a skeleton description of the sexual behavior of these animals, (2) to offer evidence to show that this behavior is motivated by dominance drive[2] as well as by

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[1] The writer wishes to express his thanks to Dr Josephine Ball of the Carnegie Laboratory of Embryology for her criticisms and suggestions. Thanks are also due to Mr. Willard Helburn of Cambridge, Mass, for his suggestions and analogies with similar human behavior

[2] The name "dominance drive" is given to the motivation factor that is assumed to be at the bottom of the high intercorrelation between the various parts of the dominance behavior syndrome. This, however, is only a deductive, theoretical concept used for the sake of economy of words The writer is very anxious that this factor not be hypostatized or mannikinized It might be better to give it a neutral designation like "D" rather than run the risk of making the "drive" into a little person behind the scenes In any case let it be remembered that the writer has never seen, heard, or touched

sexual hormones and as a consequence to maintain that sexuality is as much social as physiological in these animals, and (3) to discuss some of the implications of this two-drive theory of sexual behavior in our consideration of the social and sexual lives of monkeys.

I. Historical

While there have been several excellent researches in the field of infra-human primate sexual behavior, these have been all too few. To counterbalance these, we have a profusion of anecdotal and theoretical papers by gentlemen-sportsmen, nature lovers, and the like. Many theory-intoxicated anthropologists have been bad offenders in this respect, but are now apparently being called to order by their fellow workers [See also (21).] Too, the influence of convention has been so strong in some workers that it is not to be wondered at that this most delicate of all subjects should have suffered from the blight of taboo, which has acted to prevent much work that would have otherwise been done, and has also had a tendency to distort some of the work that has been done With these few remarks we shall turn to a brief consideration of the excellent researches that are available No attempt will be made, because of limitations of space, to discuss these thoroughly or to discuss *all* pertinent papers

G V. Hamilton (9), in 1914, broke ground with a very interesting series of researches growing out of a desire to test the Freudian hypotheses on these lower animals, particularly with respect to homosexuality and other "abnormal" behavior The problems that he set himself were: (1) Are there types of infra-human primate behavior which cannot be regarded as expressions of a tendency to seek sexual satisfaction but which have the essential objective characteristics of sexual activity? (2) Do such sexual reaction-types as homosexual intercourse, efforts to copulate with non-primate animals, and masturbation normally occur among any of the primates, and, if so, what is their biological significance?

His answer to the first question, as a result of his fairly well-con-

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a "dominance drive" He has seen and heard *only* certain behavior responses to certain social stimuli These occur with a high degree of probability, and, further, are definitely correlated into a syndrome in any single animal The writer does not wish his hypotheses to depend, for their acceptance or rejection, on any one theory of the "drive" trolled experiments, is that there are "two and possibly three, different kinds of hunger that normally impel the macaque toward the manifestation of sexual behavior, viz , hunger for sexual satisfaction, hunger for escape from danger and possibly, hunger for access to an enemy."

With respect to his second problem he finds that,

> homosexual behavior is normally an expression of tendencies which come to expression even when opportunities for heterosexual intercourse are present. . Masturbation does not seem to occur under normal conditions The macaque of both sexes is apt to display sexual excitement in the presence of friendly or harmless non-primates It is possible that the homosexual behavior of young males is of the same biological significance as their mock combats It is clearly of value as a defensive measure in both sexes. Homosexual alliances between mature and immature males may possess a defensive value for immature males, since it insures the assistance of an adult defender in the event of an attack.

Kempf (13), also influenced by psychoanalysis, studied carefully the social and sexual life of six rhesus macaques in order to obtain more insight into the phylogenetic determinants of man's social and sexual life. Generally he substantiated Hamilton's findings and enlarged on some of them He believed with Hamilton that,

> in the infra-human primates as well as in the genus Homo, homosexual interests predominate and normally precede heterosexual interests until the adult stage is well established. Homosexual interests occur in both sexes but are more common in the male. Submission as a homosexual object is implicated with biological inferiority in the infra-human primate. This is probably the root of man's conscious ineradicable recognition of homosexuality as a biological deficiency. . In the infra-human primate as in man, sexual submission is practiced to procure food (clothing), and protection

Bingham (2) has contributed an excellent study of the sexual life of the chimpanzee, genetically considered. Since this is the first and almost the only such study, it will repay careful reading[3] Generally his conclusion is that hereditary equipment must be supplemented by individual experience in the chimpanzee before its sexual behavior may become functionally efficient He reports also a good deal of variability in this behavior and establishes the fact of its occurrence in immature animals. Several other observations are of interest in connection with the purposes of this paper For instance he describes a female in such a way that we may consider it to have been dominant to the other animals, and then points out that this female was never mounted by any of the others but that *it* mounted (in a sense) the other animals. The significance of this observation will be demonstrated below.

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[3] See also recent studies of development of infra-human primate infants by Jacobsen, Jacobsen and Yoshioka (12) and Foley (6, 7) for incidental observations on sexual and dominance behavior

Yerkes' monumental atlas of anthropoid behavior (31) digests everything the literature has to offer on the study of the sexual life of the great apes Interesting comparisons between these apes are available in this volume Yerkes (29, 30) has also recorded the very interesting sexual behavior of a young female gorilla which he studied intensively Kohler (14) has contributed some useful and interesting remarks and observations on the sexuality of his group of chimpanzees, to which the reader should also refer Other studies to which some reference should be made, although limitations of space forbid any consideration of detail, are Montané (22, 23), Sokolowsky (25), Passemard (24), Fox (8), and Coolidge (5)

Zuckerman has contributed by far the most useful single study that we have available (32) It is in this book that the connection between dominance and sexuality is first pointed out clearly and discussed. Indeed it is the first clear and extended discussion of dominance behavior in general that we have. Since this work has been considered in other papers in this series we shall pass it by with this general notice.

Carpenter (4) has recently given us an unusually complete field study of the howler monkey (a platyrrhine) It is of particular interest to us because of the fact that this animal seems to display a different type of dominance behavior. Its sexual behavior in the group is very different in several important respects from the behavior of the baboon as described by Zuckerman (32). The general subject of the correlation between the howler type of dominance and its characteristic sexual behavior will be discussed more fully than would be possible here, in a future paper in this series [see also (15)].

Here we shall limit ourselves to pointing out that Carpenter reports no ownership of the female by the male, a relative lack of jealousy, nothing that looks like monogamous matings, but instead what may be very crudely described as polyandry. One female in heat may satiate two or three males. The details of the mounting behavior differ in no essential respect from the behavior we shall describe below

II THE DESCRIPTION OF SEXUAL BEHAVIOR

1. *Functional Sexual Behavior* This behavior has been variously described, although never as adequately as Stone has described the similar behavior of the white rat (26). No attempt will be made here at this latter type of description. We intend rather to set up a crude norm from which we can measure our deviations. A descriptive statement may also be found in Kempf (13), although some exceptions must be taken to this description The main point to be emphasized is the variability of this behavior from animal to animal and from species to species.

Functional copulation takes place typically in the adult pair when the female is in heat, although sexual behavior may be observed throughout the female cycle (32), and in the young and prepubescent animal [see Bingham (2)] Individual and species differences are frequent. Common to all, however, are mounting (with a few exceptions), intromission, pelvic movements of the mounting male, receptive posture in the female (presentation), and ejaculation.

Mounting may be immediate and is not necessarily preceded by genital inspection, lip smacking, chattering, or vocalization as has been claimed by many who have worked with one particular species and have consistently observed some type of behavior preliminary to mounting. Yerkes (30) has also described tremors or shivering of the entire body during sexual excitement in a female gorilla It is unwise, however, to generalize any preliminary behavior because in many cases it does not occur. Any of these, of course, *may* occur The mounting itself is also, like every aspect of the sexual behavior of these animals, very variable from animal to animal, even within the same species All we can say by way of generalization is that typically (not always) the female will stand on all fours, sometimes with forelegs bent, sometimes not. She may or may not look back at the mounting male, she may or may not vocalize. Kempf (13) describes "kissing" in his animals during the sexual act. I have never seen this in any of my animals. The female does at times turn back to the male and look at him, but their lips never touch.

The male's behavior is very hard to generalize, also because of its extensive variability The mounting may or may not be preceded by vocalization (which varies in character from species to species), genital inspection (olfactory, gustatory, visual, or manual), or other preliminary behavior. The functional mounting in most species is dorso-ventral, although there is some evidence that in the orang-outan it is normally ventro-ventral [(18) and our own observation]. In dorso-ventral mounting, the male usually grasps the female's hind legs with his feet at the region of her knees, and grasps her sides or pelvic region with his hands Entrance is made, pelvic strokes ensue, and finally there is ejaculation with accompanying excitement The male dismounts and becomes quiet, the female is apt to run about excitedly, perhaps vocalizing at the same time Any semen externally discharged may or may not be eaten by the male or the female or both.

This whole act may be repeated frequently in a short space of time, sometimes being initiated by the male, sometimes by the female For instance, when a female sooty mangabey in heat was given to a Celebes ape, twelve functional copulations were observed in a period of about a half hour. Ejaculation was positively determined in three of these acts and could not be determined in the others

Female initiation of the sexual act usually takes the form of presentation, in which she assumes a receptive posture Her tail is lifted high and her pudenda exposed to the gaze of the male If the male is not at once responsive, she may back up to him so that her hindquarters are within a few inches of the male's face She may look back at him and vocalize characteristically. This pose may be held for a fairly long time, e g, up to thirty seconds. If the male does not respond, she may intersperse repeated presentations with periods of excited running about and vocalization Sometimes the male is forced to threaten, bite, or beat her if she persists in this behavior, which seems to annoy him when he is not receptive He may also at times inspect her ano-genital region visually, manually, etc., without any subsequent mounting.

The male may initiate sexual behavior quite directly by grasping the female, and pulling her into the desired position. In many cases, however, he secures her immediate cooperation by making his desires known to her in other ways, by characteristic vocalizations, tapping her back or sides, manual pressures, etc. These sexual vocalizations vary from species to species, but are uniformly efficacious in inducing presentation immediately in the receptive female

It will be seen that even functional sexual behavior is characterized by variability rather than by uniformity When we introduce other factors that make for variability such as dominance mounting and learning or maturation of sexual responses, the picture becomes a varied one indeed. The accounts of the sexual behavior of infrahuman primates that are now extant are obviously over-simplified.

2 *Autoerotism* The occurrence of this behavior has been denied by Hamilton for his animals (9), but there seems to be little doubt that it occurs in a large percentage of isolated animals. It seems to occur more frequently in the male than in the female but it is quite certain that it does occur in the female. It occurs also, to a much lesser degree, in animals in pairs or groups. In six isolated adult males at the Bronx Park Zoo, for instance, this behavior was frequently observed in five of the animals The other animal was very old. There are no data available for animals in the wild. Yerkes (30) has reported, for his female gorilla, attempted use of the fingers of a man standing outside the cage as a masturbatory agent. Similar behavior was observed by him in a 4–5-year-old female chimpanzee. Autoerotism was observed fairly frequently in our pair of young chimpanzees even when they were together

3 *Homosexuality*. This behavior is observed very frequently in caged animals of both sexes and all ages It has been described for Hamadryas baboons in the wild (32). This sexual behavior will be of the dominance type described below rather than of the functional types already described.

4. *Female Mounting* The female monkey may mount other males as well as females. Her behavior then resembles that of the male in all respects that are anatomically possible This behavior is also of the dominance type rather than of the functional type.

5. *Ventro-Ventral Sexual Behavior*. This behavior has been seen to occur in animals that normally copulate dorso-ventrally, e.g., the

pigtail monkey, the macacus rhesus It has been observed infrequently, occurring sometimes in pairs of females and sometimes in heterosexual pairs. It has been observed only in prepubescent animals, except for two pairs of adult orang-outans, in which animals, however, this may be the "normal" procedure A possible interpretation of this behavior is submitted below.

6. *Other Forms of Sexual Behavior.* Practically all the so-called human "perversions" may also be observed in these animals, and there seem to be some more besides. The following list is offered with some misgivings about possible misinterpretation. It must be emphasized that they occurred rarely and are not at all typical. They are mentioned only because they will help to drive home the writer's thesis of the tremendous variability of sexual behavior in infra-human primates. He has confined himself only to such forms of behavior as he himself has seen in his animals

The list of rarer forms of behavior follows: Heterosexual fellatio, auto-fellatio, exhibitionism, homosexual fellatio, coprophagy, necrophilia, bestiality (sexual behavior with dogs, cats, etc.), and the use of the very young animal as a sexual object[4] These animals frequently show a specific interest in both male and female genitalia regardless of their own sexual gender. Manual, visual, olfactory, and gustatory exploration of the male organ occurs fairly frequently. Some animals have shown a great curiosity in the sexual act of other animals. Their curiosity may become so great that they may interfere with the act itself. We have already mentioned homosexuality in the male and in the female which is very common, autoerotism, eating of semen, and female mounting We shall discuss below the infra-human primate equivalents of sadism and masochism, which are also very common

7. *Individual Development of Sexual Behavior* There is little doubt now that the sexual act in monkeys and apes develops into a smooth, efficient, well-integrated performance usually through a long series of fumbling approximations and adjustments that look remarkably like trial-and-error learning [see also Bingham (2)]. It is fairly certain that some segments of the final integrated act appear spontaneously at an early age and without evidence of learning. It

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[4] These names are properly used for humans only They are used here as analogies

is probable that the adult animal who has had no sexual experience may go through the same process of trial and error fumbling that may be observed in the young animal (17). It is also certain that in an interspecies pairing, sexual adjustments are made which are certainly learned. For instance, in a pair in which a pigtail monkey was dominant and a rhesus monkey subordinate, the rhesus quickly learned the characteristic pigtail sexual vocalization and responded to it efficiently, *in spite of the fact that he had not so responded at their first meeting.*

Experiments similar to those which Stone has made with the white rat are necessary before the question can be answered in any satisfactory fashion, although it is already quite certain that the monkey's sexual performance does not resemble that of the albino rat with respect to sudden maturation.

During the course of this learning or maturation, many abnormal forms of sexual adjustment may be observed. Mounting may be on the head or side. The sitting animal may be mounted. It is only gradually that the ano-genital region is selected out for preferential sexual treatment. Various stages in the development of the mounting response itself may be observed. It may take the form of riding (as a jockey rides a horse) or of various kinds of hugging, or it may be merely a fumbling attempt to stand over the other animal.

Many of these imperfect forms of sexual response are also characteristic of dominance mounting. The latter diagnosis may be made from this behavior when previous, perfect sexual behavior has been observed.

8. *The Loss of Sexual Cyclicity.* Both the male and female may exhibit sexual behavior at any time of the month or year. Copulations may also be observed at any time during the female menstrual cycle. The heat period in the female monkey is simply a period of greater ability and of greater frequency of copulation, as Ball and Hartman (1) have shown, and *not* a period to which all sexual behavior is confined, as in the lower mammal. According to Ball this period comes at about the time of ovulation, midway between two menstrual periods.

It will be pointed out below, however, that the character of sexual behavior probably differs at different parts of the female cycle. Copulation during the heat period is more apt to be of functional type, whereas at other times it is more likely to be of the dominance type.[5]

9 *Sexual Behavior as a Channel for Repressed Excitement* Tinklepaugh (28) has pointed out that, when monkeys are excited by a stimulus with which no direct contact is possible, this excitement may expend itself in a sudden burst of sexual activity [see also Kohler (14)] Thus zoo animals that are goaded into a rage by animals in the next cage will repeatedly mount their females Zuckerman (32) has confirmed this observation using the Hamadryas baboon, and our observations on zoo animals are also confirmatory This behavior seems to be a sort of sublimation in reverse, and seems important with respect to theories of sexuality and emotion It is interesting to note, however, that at the Primate Laboratory there were two isolated animals who were habitually stimulated to autoerotic activity by the experimenter's coming to the cage

III. The Dominance Drive as a Motivator to Sexual Behavior

The papers previously published in this series (17, 18) presented considerable evidence to indicate a relationship of some sort between dominance drive and sexual behavior. The tentative conclusion was advanced that there were two different kinds of sexual behavior, that motivated by sexual drive and that motivated by dominance drive. In this section we shall attempt to establish this dichotomy more firmly by a consideration of the experimental evidence now available This can best be done by discussing (1) the general evidence for the dichotomy, (2) the behavior differences between sexual behavior determined by sexual drive and by dominance drive, (3) the characteristically different constellations of circumstances that call forth dominance sex behavior, (4) the characteristically different constellations of circumstances that call forth subordinate sex behavior, and finally (5) the evidence that disagrees with the proposed dichotomy.

It should be remembered that we are attempting no absolute dichotomy. Its two aspects are merely extremes on a continuous scale.

1. *General Evidence For the Dichotomy*

a The correlation between dominance status and sexual rôle In an experimental determination (18) of the behavior syndromes characteristic of dominance and subordinate status, it was found, after suitable corrections had been made, that the dominant animal in a pair did 98 per cent of the mounting in the pair (an average of ten dominant animals). Since this correlation was independent of sexual gender, that is, it held true whether the dominant animal was male or female, it is possible to say that dominance rôle is correlated with "male" sexual behavior, and that subordinate rôle is correlated with "*female*" *sexual behavior*. *This correlation, which is independent of* the correlation between sexual hormones and sexual behavior, indicates *certainly a* form of motivation to sexual behavior that is relatively independent of the specific motivating power of male or female sexual *hormones*. This second *motivation* we have called the dominance drive.

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[5] This is merely the writer's impression from observation He has no experimental endocrinological substantiation for this statement

b. Freedom of sexual behavior from cyclicity. Sexual behavior in the infra-human primate is not confined to a heat period. Since the *female* sexual *hormones do follow, in their incidence and function, an* anatomical and physiological cycle, it would seem reasonable to hypothesize *another factor to account for the discrepancy between non-*cyclicity of sexual behavior and cyclicity of sexual hormones. Zuckerman (32) *has attempted an endocrinological explanation of this discrepancy* by assuming that, since the sexual hormone oestrin is the *only known* cause *of sexual behavior, and that, since* sexual behavior does occur in the luteal period, therefore oestrin must exert a continuing effect even during the luteal period. *This theory is* based upon the assumption that sexual behavior is motivated only in a hormonal fashion, *an assumption that we hope to prove unnecessary*. Practically all the evidence presented in this paper constitutes a refutation of Zuckerman's theory, but we shall consider it more specifically below.

c. The separability of the influence of the sexual hormones. There are some data, however inadequate, that bear on this point in a direct way. Ball's paper (1), previously referred to, indicates a definite increase in sexual excitability in the female macaque at about the time of ovulation. Our own observations indicate also that the behavior of the female is qualitatively different in various ways when she is in (relative) heat. We have observed several cases of reversal of dominance from a dominant female to a previously subordinate male, when this female came into physiological heat. Copulations at such a time are of the functional type rather than of the dominance type Frequent "full" or physiological presentations are observed in the female at such a time. An inadequate male may, during such a period, call out behavior in the dominant female that is not observed at other times, e.g , bullying-presentation. This is the period when a male may most easily assume dominance status. Differences of social organization within the baboon harem have been described by Zuckerman that seem to depend definitely upon this same factor (32).

From such data as these we may assume the actual as well as logical differentiability of the motivating influence of the sexual hormones and the dominance drive.

d. The correlation of different kinds of dominance with different forms of social and sexual organization in infra-human primates. There is no reason to suppose that different types of hormonal organization exist in the different families of infra-human primates. Any differences in social and sexual organization that could be demonstrated to exist between these families would be logically referable to factors other than hormonal ones The writer has attempted to correlate these differences with differences in type of dominance drive existing in these families (15). Three types of dominance drive were demonstrated to exist in the three main infra-human groups that have been studied (platyrrhine monkey, catarrhine monkey, and anthropoid). The differences in social and sexual organization that have been demonstrated to exist in the first two of these groups (4, 32), were correlated with the respective type of dominance. Since the data bearing on this hypothesis are very scanty, too much should not be made of this point until further investigations fill in the gaps in the data Such studies are urgently needed if we are to understand the social behavior of these animals.

e The use of sexual behavior as a "power weapon." Sexual behavior cannot be interpreted always as a means to erotic satisfaction, especially since some behavior such as mounting by the female is very unlikely to give erotic satisfaction While the data to be discussed below all bear on this point more specifically, the general statement may be made here that much behavior can be interpreted *only* as behavior attempts to satisfy a dominance drive and not a sexual tension. Sexual behavior is used as an aggressive weapon often, instead of bullying or fighting, and is to a large extent interchangeable with these latter power weapons It may be used to subdue an annoying partner, it may be used to enforce the desires and the will of a dominant animal, and in many other ways that clearly indicate its importance as a power weapon

2 *Behavior Differences* The mounting animal in the dominance mount behaves differently from the mounting animal in the functional copulation While none of these differences are absolute, there are enough of them to make diagnosis fairly simple in many cases. All or any of the elements that we have designated as essential in the functional mount may be missing in the dominance mount, or they may be present in a merely nominal sense Erection may or may not be present (in the dominant male), entrance may or may not be made, ejaculation is much less likely to occur, pelvic movements may be completely absent, or may be very few in number, and these movements, as well as the whole performance may be of a very lackadaisical character, very different from the excitement and tension of the mounting animal in the functional mount.

Mounting may be imperfect The only desideratum at times seems to be above the subordinate animal It makes no difference at times whether this latter animal is sitting, lying on his face, on his back or on his side. The subordinate animal may then be mounted on the head, or side, or any place else. The mounting in fact may be foreshortened down to the point where it is difficult to diagnose its presence for scoring. It may, once begun, stop at any point in the behavior series Grasping the hind legs of the subordinate animal is more frequently absent than present in mounts of this kind

Generally signs of sexual excitement, as described above in connection with functional mounting, are more apt to be absent than present. Vocalizations for instance are not very frequently heard in dominance sexual behavior The mounting animal is very easily distracted by any interesting stimulus Dominant animals have often been observed to begin grooming while still mounted Food offered to such an animal will also win out over the sexual activity very frequently.

The subordinate animal, i e, the one who is mounted, will behave differently from the mounted animal in functional sex behavior Presentation again may be merely nominal and very often is. This response may vary all the way from a mere flirt of the hindquarters in the direction of another animal in passing, to the full functional presentation response of the female in heat. Sexual excitement is almost always absent in the dominance mounting in the mounted as well as in the mounting animal There may or may not be cooperation with the mounting animal The following responses have been observed in the subordinate animal in a dominance mounting. fear, apprehension, disinterest, mere complaisance, annoyance, impatience, passivity, cringing, attempts at flight, sitting, moving about, collapsing, somersaulting, fright vocalization, the "fright snarl," waxy flexibility, complete loss of tonus.

In many cases the evidence from behavior indicates that being dominance-mounted is unpleasant This is especially true for those animals that we have named "strong-dominance" animals, i.e, those animals with very strong drive to dominance, who, however, happen to be subordinate in the particular pairing under consideration because of other factors In other "weak dominance" animals, however, this may not be true.

3. *The Situations in Which Dominance Sexual Behavior Occurs* The situations and constellations of circumstances that instigate or are followed by dominance sexual behavior are so numerous that it is necessary to classify them in some way. Accordingly the following classification is offered, though with some misgivings, since it necessarily involves a good deal of anthropomorphism, and also because, to some extent, it begs the question under discussion It should be understood that it is used merely for the sake of convenience of presentation.

a When a dominant animal does not get what he wants. If the subordinate animal gets food that the dominant animal wants, if the subordinate animal does not groom the overlord when the latter has presented himself for grooming, if the subordinate animal does not submit to grooming when the dominant animal has attempted to groom him, if the subordinate animal does not at once give up any object desired by the dominant animal, dominance mounting by the dominant animal is very likely to occur A dominant female, when she has come into heat, will present to her partner for mounting. If he is afraid to do so, or is inadequate in any way, the dominant female tends to mount the subordinate animal so offending

b. To end a situation not liked by the dominant animal If the subordinate animal makes too much noise, is too active, plays too boisterously, or in any other way becomes a nuisance, it is likely that the dominant animal will mount him in an effort, usually successful, to subdue him. One animal that wriggled about a good deal while being groomed by the dominant animal was mounted frequently by the latter when such behavior occurred. The subordinate animal would then become more tractable. When the subordinate animal makes any attempt to mount the dominant animal, or if he even makes a gesture to do so, it is extremely probable that the dominant animal will mount him.

c. When a situation, desirable to the dominant animal, ends If the dominant animal is being groomed and likes it, or if he is grooming and likes it (as evidenced by his behavior), and the subordinate animal ends the situation by running away, he is likely to be mounted by the dominant animal.

d. When there is any challenge to the dominance of the overlord. Under this somewhat doubtful heading may be grouped such situations as the following· genital inspection of the dominant by the subordinate animal; too great boldness in the subordinate animal in attempting to get food; an attempt by the subordinate animal to mount the dominant animal, boldness in returning the "dominance stare" of the overlord; too great a display of attempted dominance in the subordinate animal; eating of food even after the dominant animal has spurned it. Any of these situations are liable to eventuate in mounting by the dominant animal. Mounting may also be used by the dominant animal to intimidate his partner in advance of food getting, i.e., when the food signal is given experimentally. In our experiment, in which food was dropped automatically into the experimental cage through a chute, if the subordinate animal merely looked into this chute opening, even when no food was there, he was liable to be mounted by the dominant animal.

In this same experiment, food was introduced into the situation only beginning with the sixth experimental period In many cases, this first introduction of food increased the number of dominance mountings. In a few cases, no dominance mountings occurred *until* this period.

Under this heading may be mentioned also the fact that more mountings occur in the first meetings of a pair of animals, and also that there seem to be more mountings in the first few minutes of such a meeting than there are in the last few minutes This phenomenon may *possibly* be interpreted as due to the fact that dominance is established early and this is one way in which it is done There are, of course, other possible interpretations of this behavior.

e When dominance is openly conceded (in some cases) This may seem to contradict the previous classification (of challenge to dominance). However this may be, the fact, nevertheless, remains that such behavior does occur In explanation of this apparent paradox, we can point to the general fact of bipolarity or ambivalence of behavior in everything that has to do with the dominance drive, and second, to the more obvious fact of extremely wide individual differences in strength of dominance drive, and consequently, in character of behavior Thus, in some overlords, dominance behavior is stimulated by opposition or challenge, in others, it is stimulated by lack of challenge, or too ready subordination In such animals, dominance sex behavior may be called out by flight of the subordinate animal, or by cowering, cringing, "fear-chattering," etc. (Although in other cases, this same behavior may ward off overt dominance behavior in the overlord) Subordinate presentation may call out dominance mounting, or, in other animals, it may ward it off, since by presentation dominance is conceded

f In any situation in which bullying or attack or fighting might have occurred The behavior syndrome of dominance is at the same time a unity and made up of interchangeable parts. The above classification of situations that call forth dominance sex behavior might be made to serve equally well for a canvassing of the situations that would call forth bullying, simply by substituting the word "bully" for "mount." The contrary proposition may be stated thus: any situation that is adequate to call forth bullying behavior is also as adequate and as likely to call forth dominance sex behavior.

g. Dominance sex behavior in the subordinate animal The dominance drive is not cyclic but continuous The data indicate that it is best to think of it in the subordinate animal as continuously active, and always trying[6] to express itself in dominance behavior even when in the subordinate status Thus, whenever there is any possibility of doing so, the subordinate animal will behave in a dominant fashion The following instances of such behavior have been recorded during the writer's experiments.

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[6] Such anthropomorphic expressions are used here only because of space limitations

In inter-species pairings, it has been possible to determine that one or the other animal was dominant The behavior syndrome has often not been as perfectly intercorrelated as in like-species pairings. For instance, in pairing a green monkey, which was a very fast but timid animal, with a macacus rhesus, which was a comparatively slow but dominant animal, it was found that the macaque was dominant in all behavior but food getting The green monkey was so speedy that he could get the food far more easily than his partner as it dropped from the food chute. The continual efforts of the macaque to enforce his dominance (sexually and otherwise) were futile because it was possible for the green monkey to avoid his rushes very easily

Any weakness in a dominant animal is immediately seized on and exploited in the dominance struggle A dominant macaque that had somehow sprained his ankle was soon flouted by the subordinate animal whom he had dominated completely previously Among macaques, a sick animal is often beaten or bullied to death, even though it may have been dominant before

The strong desire of a dominant animal to groom or to be groomed may be thus played upon by the subordinate animal to satisfy at least partially his own dominance drive. Several dominant animals, who were strong groomees (liked to be groomed), were regularly mounted by the subordinate animal, upon presentation for grooming The dominant animal would often allow this mounting for a moment or two, if it were followed by the strongly desired grooming

4 *The Situations in Which Subordinate Sex Behavior Occurs.* The dominant animal will present (assume the female sexual position which is also usually the subordinate sexual position) in the following situations: a dominant female will present when in heat; a dominant animal will present to get what it wants, e g, grooming, when mounting or bullying are of no avail; to attract or lure the subordinate animal so that he may be bullied or mounted; in play (see the first paper in this series). The dominant female may behave in a way that we have called "presentation-bullying." She will present to the subordinate animal and at the same time bully him with her hind legs Sometimes in this position she may back up closer and

closer to him until finally she passes right over him into a mounting position The dominant animal may also present in a fashion that can only be called teasing He may present and allow the subordinate animal to approach and almost mount, only to turn on him (not viciously, however) and snarl or growl or bully him. This may be repeated several times, but usually the subordinate animal does not repeat the performance after one or two attempts.

The subordinate animal may present in the following situations: after getting food, if the dominant animal is annoyed or shows any resentment or anger, upon aggressive approach of the dominant animals, after, before, or during bullying or attack; to keep food already obtained if the dominant animal approaches, on genital inspection by the dominant animal; upon approaching the dominant animal to sit near him or to groom him; when the dominant animal indicates his desire to mount, when the subordinate animal has been too bold; when the dominant animal stares at him in a specific way which the writer has called the "dominance stare"; during the very first moments of the first meeting with an animal who turns out to be dominant.

Any animal may present to a strange, or unknown, or fear-inducing stimulus. This may at times be interpreted as a question of propitiation or subordination, and at other times as a gesture of friendliness. For instance, a young mandrill, seeing a lighted match for the first time, touched it and was burnt Immediately he presented "fully" An overlord, who had bullied his partner into a state of terror, now wanted to be groomed Whenever he approached his subordinate, however, the latter curled up and cringed instead of grooming, whereupon the overlord presented to him. This seemed to be reassuring and an indication that no further violence was intended, and the subordinate at once started grooming.

5 *Contrary Evidence* Some evidence may be marshalled against the dichotomy here proposed While the writer feels that the negative evidence is far outweighed by the positive evidence, he also feels that the reader had best decide this for himself. The following facts throw some doubt on the validity of the distinction and must be explained away in any final statement of the problem

There is some evidence that true sexual excitement is at times involved in the dominance sex relationship. Dominance mountings, in a few instances, have been observed to be stimulated by the heard sex grunts of copulating animals in a neighboring cage or room. Also autoerotism seems to decrease in a dominant animal who has engaged only in dominance mountings during the experiment Again, it should be pointed out that while any or all the essential elements of the functional sex behavior *may* be absent in the dominance mounting (and most often are), these same elements are often present in the dominance mounting to a large extent, although rarely as completely as in functional mounting. Thus sex vocalizations may be present in some dominance mountings. Erection is fairly frequently observed in the mounting male (and peculiarly enough, in the mounted male as well).

The sexual value of the subordinate sexual position is a very puzzling matter The evidence bearing on the question is vague and contradictory. For instance, in addition to the note above on erection in the mounted male, we might mention also the case of a subordinate macaque male, who practically always masturbated while being mounted by the dominant animal. The fact also that dominant males or females may mount the subordinate male or female after accidental glimpses of the genitalia of this latter animal indicates a possible specific attraction value of these organs, in which, however, no distinction is made between male and female genitalia

It should also be mentioned that a few dominance mountings, which were diagnosed as such because of the stimulating situation, behavioristically looked almost like true functional mounts, so that, if observed alone without knowledge of the situation, they might have been diagnosed as functional rather than dominance mounts It has looked sometimes, in cases like this, as if the original motivation was dominance, with the performance changing in character as it was found to be erotically pleasant. Thus the dichotomy is *very far from being a sharp one.*

Another fact that should be emphasized again is that what we have done was to point out the two extremes of a continuous scale of behavior A distinction between dominance sex behavior and hormone sex behavior would never have been noticed or made, if the middle ranges of the scale of behavior alone had been observed. It was only through observation of the extremes of the scale of behavior that the distinction was noticed and carried over to the middle, more doubtful cases of sexual behavior

So far as reproduction is concerned, also, there is probably little doubt that what I have called a dominance mount *might* eventuate in impregnation and production of offspring in adult animals. The descriptive term "functional mount" must remain a relative one

6 *Summary* With the preceding considerations the writer has attempted to convey what is much better and more convincingly driven home by a few hours' observation of the behavior of these animals under the proper conditions. That a simple explanation of their sexual behavior in terms of sexual drive alone is completely inadequate is, we think, an established fact When we add to this drive the motivating influence of the dominant drive, we have a much more valid explanation of the characteristic sexual behavior of the infra-human primate This "two-drive theory" may eventually be turned into a three- or four-drive theory, or the dominance drive itself may be explained on an endocrinological basis.[7] However that may be, on the basis of the evidence now in hand, we must allow for a more complex motivation of sexual behavior in the monkey than the science of endocrinology has hitherto thought necessary.

IV. SOME IMPLICATIONS OF A TWO-DRIVE THEORY

1 *Freedom from Sexual Cyclicity* We have already mentioned the fact that the sexual behavior of the monkey is not confined to a heat period but may occur at any time of the year, month, or during any period of the female menstrual cycle The tendency thus far has been to explain this anomaly in endocrinological terms. Heape, for instance (11), labels it "abnormal oestrous behavior." Zuckerman (32) has made a more systematic attempt to explain this behavior in terms of a continuing effect of the oestrin hormone through the luteal period

We shall make no attempt to criticize this theory on an endocrinological basis except to point out the lack of evidence (even endocrinological) to support it. The scanty data adduced by Zuckerman in its support are suggestive but by no means conclusive or even convincing. We shall instead confine our efforts to demonstrating our alternative theory and pointing out the various ways in which it fits the behavior data in an explanatory way.

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[7] For instance, there is some indication now that both men and women produce both the male and female sexual hormone It is at least conceivable that the behavior we have described may eventually be considered to be a function of the variable interplay and balance of these two hormones in the same organism.

We submit that a consideration of the dominance drive as a motivator to sexual behavior, when added to the sexual drive, is adequate to explain this freedom from cyclicity. If it were possible to disentangle the sexual effects of the dominance drive from the sexual effects of the sexual drive, we should probably find that the sexual drive in the female follows roughly such a cycle as we find in the lower mammals. The rough facts of this cycle are now known on the anatomical side. Ovulation comes approximately at the midway point between the beginnings of two menstrual periods. During the period before ovulation, the oestrin hormone[8] is the most potent endocrine determiner of behavior; during the period after ovulation, the corpus luteum hormone[8] is the most potent determiner of behavior. The influence of the oestrin hormone seems to rise to a peak a day or two before ovulation. Ball and Hartman (1) found this to be true for sexual excitability in the adult female *macacus rhesus,* although some animals showed no difference of behavior throughout the cycle. At this time the copulations that occur seem much more likely to be functional in nature, and they seem to occur more frequently.

If we take this physiological rhythm as fundamental, we find superimposed upon it all the sex behavior determined by dominance. As we have shown, sexual behavior may be independent of sexual excitability or desire. Since dominance drive is not cyclic but continuous, we have sexual behavior occurring at any time during the cycle.

Stated briefly then, this hypothesis holds that the freeing of monkey sexual behavior from cyclicity is due largely to the superimposing of socially motivated sexual behavior upon the hormonal cycle. The pattern of hormone-determined behavior is fundamental and takes precedence over dominance-determined sexual behavior, especially in the period just before ovulation, and probably also in the longer "oestrin period" before this. But when these prepotent physiological factors are not operating or are at a low ebb, then we have clearly coming into prominence another kind of motivation and another kind of sexual behavior It is the resultant of these two types of motivation that gives us the sexual behavior picture that we actually observe in these animals This does not mean that the two types of motivation are distinct in their effects, nor that the two kinds of sexual behavior are easily distinguished It is highly probable that many individual sexual acts are the resultant of both drives, and that these two drives generally intermingle and join to produce a common effect.

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[8] Or hormones.

This theory will also explain satisfactorily the frequent appearance of homosexual behavior, prostitution behavior, and many other kinds of behavior that the endocrinological theory cannot at the moment deal with.

One other fact is very important in this connection. To say that sexual behavior occurs in monkeys at any time is inaccurate In some pairs it may *never* occur, as so many authors have reported[9] If the female is dominant to the male it may never occur except in the form of dominance mounting *by the female only* In other cases, when a female is not too markedly dominant over the male she is with, she will present to him and functional copulation will ensue only when she is in heat, and at no other time Such behavior patterns as these cannot be explained endocrinologically.

2 *"Prostitution Behavior" in Monkeys.* What has been called "prostitution behavior" in monkeys may be understood in a broader frame of reference in the light of the previous considerations Economic goods that are ordinarily unavailable to a subordinate animal become at least partially available to him when he concedes dominance by assuming the female sexual position We must understand that he is ordinarily cut off from access to these economic goods because he does not dare challenge the dominance of the overlord by avail-

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[9] "Some females have, however, consistently refused the male, and certain ones have an antagonism to one or the other of our males but the stage of the menstrual cycle has nothing to do with their refusal or acceptance" Hartman (10) Many such quotations are available in many other studies Just as frequently do we meet with interpretations in terms of "antagonism"

ing himself of them. Obtaining a piece of food apparently has two meanings for monkeys. (1) it is a source of hunger appeasement and (2) it is also an assertion of dominance. If the subordinate animal can assure the dominant overlord that he means no challenge to dominance, then the overlord, if he is not hungry, may allow him to get the food. The method par excellence of showing subordinate status seems to be an assumption of the female sexual position (*presentation*) *To interpret such behavior as an economic* transaction in which sexual satisfaction is offered in exchange for economic goods, *quid pro quo*, seems to be an unsatisfactory interpretation The presenting monkey is offering not sexual satisfaction but social submission

3. *Homosexual Behavior.* This behavior is easily explained as dominance and subordination behavior An animal will mount another animal of the same sex to assert dominance; and an animal will present to another animal of the same sex to admit subordination. To interpret such behavior as an abberation of the sexual drive or as an endocrinological abnormality is to go far astray. To the human observer the fact that the animals behaving sexually are of the same sexual gender seems very important and he gives it the special name of "homosexual" behavior Actually this is an artificial, man-made abstraction from a large mass of homogeneous behavior, namely, dominance mounting It is important and significant only to the human, and not to the monkey, that a male overlord mounts a subordinate male rather than a female This means no more and no less than dominance-mounting a subordinate female

4 *The Unmounted Female, and Other Non-Reproductive Phenomena* Cases in which a female is never mounted by the males in her group, or in which the female mounts males or other females instead of being herself mounted, or in which a male will mount other males in preference to females, are probably all explicable in the same terms that we have used above The female who is dominant to all the males in the group will not be mounted by any of them except when she comes into heat, and possibly not even then, if she is *very* dominant, for they will fear her even when she presents The animal who is mounted by the overlord for the assertion of dominance may be either male or female However, it will not be mounted *because* of its male- or femaleness; it will be mounted be-

cause of the strength of its own dominance drive, which is independent of its sexual gender.

On the surface, then, it might seem as if the dominance drive, because of its peculiar workings, was non-biological, in the sense that it had negative survival value for the race or species. Closer examination of the facts will convince us that this is not true, however In the first place the fact of sexual dimorphism insures generally the dominance of the male over the female in the wild In our experiments this factor of sexual dimorphism was deliberately controlled by matching for size and also by choosing animals of like sex for pairing. The fact is, then, that the usual male superiority in size and strength is not without survival value. It insures for these animals in the wild a fitting of the dominance drive and its manifestations into the general picture of survival of the species. It indicates also a very important social value for this fundamental anatomical fact.

In the second place there is some indication that a dominant female coming into heat loses her dominance and assumes the ordinary "female" rôle in sexual behavior. This fact (if it be found to be a fact) is also shown thus to be of survival value

In this connection it is interesting to consider the difference between the infra-human primate and, say, the guinea-pig or the white rat. This latter animal has been shown by Stone (26) to display specific maturation of the sex-drive and also of sexual behavior. A young male, without any sexual experience whatsoever, will show an astonishing perfection and adequacy of behavior the first time he mates with a female What in the monkey takes the place of this perfection of maturation in which learning need play no part? What takes the place of specific stimuli to sexual behavior? So far as is known there are none that are nearly as definite as those we find in the lower animals. The writer suspects that this question has at least some light thrown upon it by the preceding considerations.

5. *Sadism-Masochism* Sadistic behavior seems to be dominance behavior and masochistic behavior seems to be subordination behavior It is to be doubted that these behavior types are direct manifestations of the sexual drive as has hitherto been thought, although it is very easy to understand just why this mistake should have been made Sadism and masochism are very definitely con-

nected with sexual behavior, but it is our conviction that this connection is with sexual behavior of the dominance type, and that they are alike manisfestations of something deeper, the dominance drive in its two aspects of dominance behavior and subordination behavior.

6 *Jealousy* Oftentimes we see behavior in the infra-human primate that can be described only as jealous behavior The interpretation of such behavior in terms of outraged dominance, challenge or affront to dominance, etc , is at least a possible one even if it is also a very risky one. We wish at this point merely to suggest that this question may be elucidated by further research with the dominance drive.

7 *The Divorcing of Sexual Behavior from Reproduction.* To this day, many psychologists speak of sexual and reproductive behavior as if they were synonymous The absurdity of such a contention has been amply demonstrated by the facts presented in this paper. While sexual behavior *may* be reproductive it is not necessarily so, and as often as not, actually is non-functional or non-reproductive.

8. *Ventro-Ventral Sex Behavior* We are inclined, on the basis of the inconclusive evidence that we have, to interpret this behavior as the means whereby an animal with strong dominance drive, who has been *forced* into a subordinate position, may avoid the (for him) obnoxious subordinate sexual position We suspect that it may also mean equality of dominance.

This behavior, with one exception, occurred only in pairs in which the subordinate animals had a strong drive to dominance. In our zoo observations (17), this behavior occurred in two groups. In group nine, the young male mandrill who was subordinate to the female, nevertheless was a very aggressive animal and seemed to have a strong drive to dominance. Ventro-ventral sex adjustments were observed twice in this pair. The same behavior was observed in a group of pigtail monkeys (group 5), under the same circumstances. It was never seen to occur in monkey groups in which the overlord was completely dominant

In the laboratory experiments (18), this behavior, with one exception, again occurred only in pairs in which the subordinate animal had strong drive to dominance (Pal-Psyche, Jill-Jack, Spitter-

Glenny, and Roughie-Toughie) These pairs were the only ones in which the subordinate animals were "strong-dominance" animals. The one exception to this tentative rule was observed in the Psyche-Percy pairing, in which Psyche, the dominant animal, initiated this behavior three times. Since he had previously been paired with Pal (in which pairing there was much struggle for dominance), this exception may perhaps be interpreted as a habit carry-over. Certainly it is significant that when he was paired with Pal, Psyche initiated this behavior 118 times in 25 periods, whereas when he was paired with Percy, a completely subordinate animal, this behavior occurred only three times in 30 periods.

In a more recent experiment, not yet reported (19), in which 12 pairings were made, this behavior occurred only once, and here too in a pairing in which the subordinated animal displayed an extremely strong urge to dominance.

The status of this behavior in apes seems to be somewhat different and it is doubtful that the above interpretation would hold for them. It has been observed in the gorilla (29, 30), the chimpanzee (29), and in the orang (8). Our pair of chimpanzees at the zoo (17) also at times exhibited this behavior The male, who was dominant, lay on his back and invited the subordinate female to come to him by spreading his arms and legs wide She usually responded by coming rapidly and lying on him. The keeper of the zoo reported the same behavior for a pair of orang-outans which had died before our experiments began. The female, who was dominant, invited the subordinate male to sexual activity in the same way In these orangs and in those reported by Fox (8), this was the only form of sexual behavior observed and it may be the "normal" way for these animals In our pair of chimpanzees and in those recorded in the literature, this behavior was interspersed with ordinary dorso-ventral mounting by the dominant animal.

The door is wide open to guesses as to the interpretation of this behavior in the apes Our own guess would be that this behavior has something to do with the different kind of dominance drive observed in the anthropoid apes It would seem to us to go along in some way with their greater friendliness and mutuality of behavior. Obviously, however, more data are needed before more valid hypotheses may be made

IV. SUMMARY

A brief description of the sexual behavior of infra-human primates emphasized the profusion of sexual behavior, both in amount and variability

Various considerations were then discussed that made it seem valid to consider the dominance drive as a motivator to sexual behavior. If this is admitted to be true, then all sexual behavior may roughly be divided into two types, that motivated mainly by the sexual drive, and that motivated mainly by the dominance drive The latter type may be used as a power weapon, and as a form of gesture language with which social attitudes are communicated.

Various baffling problems of social and sexual behavior in these animals may be cleared up, at least partially, by an application of this "two-drive" theory. The problems discussed were (1) freedom from sexual cyclicity in the infra-human primate, (2) the so-called "prostitution behavior" of these animals, (3) homosexual behavior, (4) the unmounted female, and other similar non-reproductive phenomena, (5) sadism-masochism behavior, (6) jealousy, (7) the general problem of the separability of sexual behavior from reproductive behavior, and (8) ventro-ventral sexual behavior.

Nothing has been said in the body of the paper concerning the human (advisedly). It is, however, very obvious that the techniques of experimentation and theoretical application discussed for the infra-human primate strongly suggest reconsideration of similar human behavior in their light. For instance much that has been said here could be profitably compared with similar data and conclusions drawn by Adler and his school for the human. We call particular attention to the close similarity between our concept of dominance drive and the Adlerian concept of "masculine protest."

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THE DEVELOPMENT OF THUMB OPPOSITION IN THE HUMAN INFANT

From The Yale Clinic of Child Development, New Haven, Connecticut

ARNOLD GESELL AND HENRY M. HALVERSON

I INTRODUCTORY

Wood-Jones, who has written so suggestively about the hand of man and of the infra-human primate, says that the "subject of thumbs and big toes has provided an arena in which anatomists, philosophers, and even divines have met and done battle." He believes that the human thumb has received excessive praise from philosophers and reminds us of the "beautiful little hand" of that interesting primate, *Tarsius spectrum*, which he characterizes as a humanoid living fossil. This very primitive creature, about the size of a rat, has an opposable thumb (11).

Even a plantigrade mammal like a bear has some elementary powers of opposability We have observed a nine-year-old honey bear in the New York Central Park zoo "manipulating" the stick of a lollypop which he licked with almost human avidity and perseverance. In solving this mechanical problem he assumed a supine and occasionally a semi-sitting position He clasped the stick at times between his forepaws His preferred method of holding, however, was by superimposing his right palm upon the sole of his upturned left or right foot. Thus he held the stick, as within a clamp, accomplishing the further adjustments to the candy knob by amusing postural contortions of head, shoulder, and trunk Thumb opposition in combination with increased mobility of the forelimb reduces the necessity of such massive contortional motor coordinations It doubtless saves mechanical energy.

Thumb opposition subserves the finer needs of manipulation It may be thought of as a more delicate form of opposability which by evolution was grafted into that remarkable system of levers which even a president of the British Association of Science has called "the most complete and perfect mechanical organ Nature has yet produced"

Lest we be carried away by this eulogium, the anatomist reminds us that the skeleton of this hand is amazingly like that of the ancient tortoise who for millions of years swam the seas and walked the earth before the advent of man. The human hand remains "a strangely and almost shockingly primitive survival."

The thumb, however, can claim a superior status among the digits. Even though "all thumbs" is proverbially synonymous with awkwardness, the human thumb is the most highly prized member of the entire hand. Its special status is well reflected in provisions of workmen's compensation acts such as the Connecticut Statute (5237 Revision 1930). This statute, having specified the compensation for disability, adds provisions for additional compensation at a given rate in terms of weeks as follows:

Loss of arm	255 weeks
Loss of hand	175 weeks
Loss of thumb	60 weeks
Loss of forefinger	38 weeks
Loss of middle finger	30 weeks
Loss of fourth finger	25 weeks
Loss of fifth finger	20 weeks

In the eyes of the law the digits assume increasing importance from the ulnar to the radial position. The loss of a single phalanx of the thumb is reckoned as half of the total loss, namely one-half of 60, or 30 weeks, the loss of a single phalanx of any other digit earns one-third of the compensation values assigned to that digit. For example, one-third of 30 weeks for the medius, or 10 weeks The law, therefore, regards the loss of a single phalanx of the thumb as about three times more serious than the phalanx of any other digit

II. ANATOMICAL CONSIDERATIONS

The thumb is the shortest of the five digits, but it cuts the largest figure in more than one sense. We have made the following demonstrations. The adult hand was bound in a broad splint The splint was then rested pronately upon a table in such a way (see Figure 1) that all of the digits extended over the table edge to permit their unrestricted movement Each digit was surmounted with a stylus which was made to record on a vertical surface The subject was

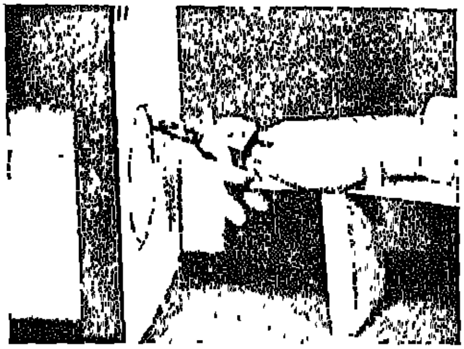

FIGURE 1
DEVICE FOR DEMONSTRATING DIGITAL CIRCUMDUCTION (ADULT HAND)

then instructed to describe an oval of maximum size by circumduction of each digit. Figure 2 shows the results of this simple experiment. It will be readily seen that the thumb is the most mobile of all the digits.

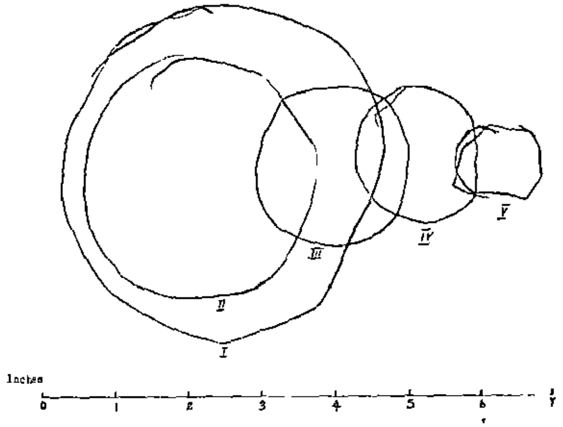

FIGURE 2
RECORD OF CIRCUMDUCTION MOVEMENTS OF DIGITS OF ADULT RIGHT HAND, WITH METACARPUS HELD PRONATE IN A TIGHTLY BOUND SPLINT AS PICTURED IN FIGURE 1
The recording stylus extended two inches beyond the tip of the digit

The tracings of the adult digits give a preliminary hint of the course of development of thumb movements in an infant In the early stages these movements are not under voluntary control When they occur spontaneously they tend to describe back and forth arcs and irregular or flattened ovals, somewhat comparable to those of the mature conjoint digits Tracings of typical excursions of the thumb at advancing ages, could they be secured, would provide an interesting graphic outline of the developmental progression which culminates in voluntary circumduction

If in the adult experiment just described the conditions of the test are equalized for all the digits, and if the splint is widened to immobilize the thumb as well at the *metacarpo*-phalangeal joint, then the scope of circumduction by the thumb becomes nil. The action at that joint is that of a mere hinge The pivotal ranginess of the thumb is due to the mobility at the *carpo*-metacarpal joint The distinctive trait of thumb opposition is based upon this anatomical fact The longest axis of straight flexion-extension movement in the thumb is in a horizontal plane; the longest axis of the associated digits (II, III, IV, V) is in a vertical plane

These relationships permit the volar surface of the matured thumb to come by circumduction into full opposition to the corresponding volar surface to each remaining digit, including minimus The opposition between the index finger and the thumb is of greatest practical importance Thumb opposition in the fullest sense of the term, however, is not attained until the entire gamut and full degree of opposability to all the associated digits has been achieved It will be convenient to designate these four associated digits collectively as the "conjoint digits"

The common carpo-metacarpal joint of the conjoint digits has a single articular cavity which permits only slight movements In contrast, the carpo-metacarpal joint of the thumb is the most pronounced saddle joint in the body It has independent articulation with the trapezium Like all saddle joints it is biaxial The surfaces being incongruent, the movements about the two axes can be so combined that actual circumduction is possible The chief movements of the thumb are *abduction away from the index, adduction,* and opposition. During opposition (which is an extreme phase of circumduction) the concavity of the palm is greatly increased.

Minimus (Digit V) is richly supplied with muscles. Ordinary opposition is accomplished by coordinated action of six muscles, namely. *Abductor policis brevis, Opponens pollici, Flexor pollici brevis, Digitorum sublimis, Digitorum profundis, Flexor brevis indicis* In the case of opposition between thumb and minimus, the *Opponens digiti quinti* and the *Flexor digiti quinti* and the *Abductor digiti quinti* are brought into play

Although the present study is mainly concerned with the thumb, the very nature of thumb opposition requires also some consideration of the index or forefinger. The specialization of the human index finger is developmentally a fact of coordinate significance. Structurally this specialization consists in an unusual degree of stability in the metacarpal bone of this digit Functionally the specialization expresses itself in the last quarter of the first year of human infancy in characteristic propensities and patterns of poking and probing. In infra-human species, thumb and index have been called the "toilet" digits. Yerkes might perhaps call them the "grooming" digits. In any event, these terms are good reminders of ancient chapters of prehistory

The topographic and developmental anatomy of the infant thumb as compared with the thumb of the adult would repay more investigation than we have expended on the problem The following table of

TABLE 1

COMPARATIVE MEASUREMENTS OF INFANT AND ADULT HANDS

	Girl infant hand 12 wks. cms	Girl infant hand 52 wks. cms.	Woman's hand cms	Infant. Adult ratio at 12 wks	Infant. Adult ratio at 52 wks
Palmar length of hand wrist to medius	7.2	8.9	L 17.5		
			R 17.5	2.43	1.96
Volar length of medius	3.2	4.0	L 7.5		
			R 7.5	2.34	1.87
	Boy infant hand 9 wks cms	**Boy infant hand 49 wks cms**	**Man's hand cms**	**Infant Adult ratio at 9 wks**	**Infant Adult ratio at 49 wks**
Palmar length of hand wrist to medius	7.5	9.6	L 20.0	2.66	2.08
			R 19.5	2.6	2.03
Volar length of medius	3.3	4.1	L 8.7	2.63	2.12
			R 8.4	2.54	2.04

measurements (Table 1) should be borne in mind in appraising the ratio between the dimensions of the infant's hand and the objects which he grasps in the experiments about to be reported. These objects include a cube and a ball 2.5 cm. in diameter, a larger ball, 6.3 cm. in diameter, a pellet 7 mm. wide and a string 1 mm. thick.

The infant's hand at one year, it will be noted from the foregoing table, is approximately one-half its adult size. The standard one-inch prehension cube would have to be replaced by a two-inch cube to establish the infantile size for the adult hand relationships. This would increase the weight from a quarter-ounce to a full ounce

III. PREVIOUS DATA ON THUMB OPPOSITION

Since scientists, philosophers, and divines have all been interested in the phenomenon of thumb opposition, a lengthy bibliography could be compiled No attempt will be made to summarize the extensive literature It is full of unresolved problems arising partly out of the lack of a clear-cut definition of the act of thumb opposition.

Says Wood-Jones "looking broadly at the mammals, we may say that the preservation and elaboration of the inherited mobility of the forelimb is an essential for the culmination of evolution" (11, pp 216-220, see also 12, pp. 197 ff). Does the same principle extend to the specialized mobility of the thumb? Osborn apparently thinks so for he says:

> We observe also in the chimpanzee a contrast between the grasping power of the big toe, which is a kind of thumb, and the lack of that power in the hand, in which the thumb is nearly useless; in all apes this function is characteristic of the foot; in man, of the hand alone The *opposable thumb,* with its power of bringing the thumb against each of the fingers, is the one character which is lacking in every one of the anthropoid apes and which was early developed among the ancestors of man (8)

Yerkes notes, however, that, in contrast with certain monkeys, the anthropoid apes "in finer grasping movements of fingers and toes are relatively unskillful" (14).

Wood-Jones holds that the mere anatomical arrangement by which opposition may be produced among the digits is not a necessary part of the characteristics of the primates, nor is it wholly within their phylum that it is displayed

> Some of the very thoroughly arboreal Marsupials have perfected this arrangement, and most of the Phalangers possess an opposable big toe Even developments such as are seen in the Chameleon, among the Reptiles, and in the Parrots among the Birds, are hinted at in the hand of the *Koala* (*Phascolarctus*) in which the two inner digits tend to be separated from and opposed to the outer three. Certain arboreal Rodents have developed very perfectly opposable thumbs and the big toes upon lines exactly similar to the Primates, and this feature is seen very beautifully in an arboreal mouse (*Mus margarettoe*), discovered by Charles Hose in Borneo (12, pp 67-69)

The earlier observations of thumb opposition in the human were made in connection with the observations of individual children and must be sought in diaries of infant development. For the most part these observations are incidental Gesell (2) reports observations in connection with normative studies. Gesell and Thompson (3, pp. 115, 116, 180-205) report more detailed and diversified data in the volume on Infant Behavior. Castner frequently refers to thumb reactions in his analytic study of pellet prehension (1). Direct attacks on the problem of thumb opposition were made by M C Jones (10) and by Halverson (6, 7), both of whom present data showing the frequency of occurrence of this type of thumb posture in grasping an inch cube.

A review of this literature would reveal apparent contradictions and not a few uncertainties, arising out of obscure or over-simplified criteria for the behavior pattern called thumb opposition.

IV. THE PRESENT EXPERIMENTAL STUDY

Because of the scientific importance of the problem, it seemed desirable to define more precisely the criteria of thumb opposition and to trace the course of its development. For this purpose we collected observations on seven boy infants and ten girl infants, comparable in socio-economic status and general capacity to the subjects used in the Yale normative survey. The observations were limited to the prehensory reactions which were systematically recorded by 16-mm cinema film

At the early age levels the infants were observed in the supine as well as the sitting position Standard procedures were similar to those used in the normative examination. If the infant had not acquired the capacity for independent sitting, he was placed in a supportive chair. Otherwise he sat on the platform of a clinical crib, as described elsewhere (5). The infant is confronted with a table top resting on the side panels of the crib. This examination table (table top) is marked with location points and lanes in order to control the spatial aspects of the procedure

Four objects were usually presented in the following order: rod, cube, ball, vertical string, horizontal string. The string was presented with the table top removed to permit freedom of approach and manipulation The actual procedure may now be summarized in the present tense as follows:

> The examiner stands at the child's left at the head-end of the crib and almost completely out of direct range of the child's vision The child is seated in the examining chair or on the platform, looking forward with hands in an unconstrained position. The examiner takes the cube out of the pocket of the container or out of his smock and, remaining in the background, he circuitously approaches the farther edge of the table top with the cube in his hand. He holds the cube in horizontal plane between the index finger and thumb and then brings it into the child's view. If the child is not looking in the direction of the object, the examiner waits for a favorable moment for the further presentation of the cube He then advances it in a horizontal plane about two inches above the table top and places it noiselessly in the standard median position He uses about two seconds to advance the cube from the table edge to this position. (The tips of his fingers traverse the median plane) He withdraws the hand promptly with moderate dispatch, avoiding sudden movements He remains near the corner of the crib so that the child may give undivided attention to the cube If the cube is not contacted by the infant, it is left in position ten seconds. The examiner then advances it in a similar manner to the near median position.

At appropriate age levels the examiner inserted an object in the ulnar aspect of the infant's hand in order to determine acceptance for or resistance to the presentation All of the observations were made in the photographic dome of the Yale Clinic of Child Development. Sixteen-millimeter motion picture records were made from a 45° frontal position by means of a camera equipped with a four-inch lens The films[1] were later analyzed with the aid of a projection desk. The major results of the analysis are compiled in subsequent tables.

V POSTURES OF THUMB AND CONJOINT DIGITS

Thumb and finger postures were first analyzed in great detail. The classification of thumb postures listed in Tables 2 and 3 is based on this analysis. A finer classification is possible but irrelevant for the purpose of this study. The items of the table are to a considerable extent self-explanatory. *Back of the object* refers to the surface of the object which is most adjacent to the palm. The *adjacent surface* is that face of the object which is exposed at the radial aspect of the closed hand. *Flexed down outside parallel to rod* refers to the thumb which is sharply flexed exterior to the finger tips with its mesial edge against the rod or finger tips. The *partly adducted* and *partly opposed thumb* (*semi-opposition*) refers to this digit when it is midway between simple adduction and full opposition. [In

TABLE 2

DIGITAL POSTURES IN GRASPING CUBE AND BALL

	Age in weeks							
Thumb posture	16	20	24	28	32	36	44	52
Adducted back of object	6	—	1	—	—	—	—	—
Adducted front of object	1	—	—	—	—	—	—	—
Adducted vs adjacent surface of object	23	32	21	18	6	4	1	1
Partly adducted, partly opposed	1	—	7	5	4	3	—	2
Opposed	—	—	—	11	16	22	33	29
Fingers which hold object								
2, 3	2	4	4	11	12	8	25	17
2, 3, 4	5	3	9	5	3	12	7	11
2, 3, 4, 5	7	8	6	8	6	4	1	2
2	—	—	—	—	1	2	—	1
3, 4	2	6	4	3	2	2	1	1
3, 4, 5	10	7	6	6	2	1	—	—
4, 5	4	4	—	1	—	—	—	—
4	1	—	—	—	—	—	—	—

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[1] The authors have organized illustrative cinema records into a one-hundred-fifty-foot instructional reel

TABLE 3

Digital Postures in Grasping Rod

Thumb posture	Age in weeks 16	20	24	28	32	36	44	52
Thumb behind rod								
Flexed into palm	3	—	—	—	—	—	—	—
Resting on medius or forefinger	5	4	2	3	—	—	—	—
Thumb in front of rod								
Abductive extension	1	—	1	1	2	—	1	—
Flexed into palm	1	1	—	—	—	—	—	—
Resting on medius or forefinger	2	5	5	1	1	—	1	1
Flexed down outside, parallel to rod	3	4	1	1	1	—	—	—
Partly adducted and partly opposed	—	1	4	6	5	1	—	2
Opposed volar thumb vs dorsum of fingers	—	—	—	6	9	17	16	15
Fingers which hold object								
2, 3, 4, 5	2	9	10	8	15	14	16	8
2, 3	—	—	—	1	3	1	2	5
2, 3, 4	—	—	—	1	—	2	—	4
2	—	—	1	—	—	1	—	1
3, 4	2	1	—	4	—	—	—	—
3, 4, 5	9	4	2	3	—	—	—	—
2, 5	—	—	—	1	—	—	—	—
4, 5	—	1	—	—	—	—	—	—
3	1	—	—	—	—	—	—	—
2, 4, 5	1	—	—	—	—	—	—	—

adduction the volar aspect of the thumb forms an angle of 90° with the palmar surface, whereas in direct opposition, the direction of the closure by the thumb forms practically a straight angle (180°) continuous with the direction of closure by the opposing fingers.] For simplification the categories in Tables 2 and 3 are later reduced to three in forming Table 5. For example, from Table 2, Cube and Ball, the first three items fall under the general category *Abduction* or *Adduction*. From Table 3, the first six items are included in this category.

It will be noted that up to 28 weeks the thumb is most often found adducted against that portion of the ball or cube which is adjacent to the forefinger. At 24 weeks seven instances were found in which the thumb postures show some pivoting toward opposition. Opposition is not yet fully developed; the thumb does not completely circumrotate to a position on the object which bears directly against the pressure of the fingers. The thumb is still partly adducted toward the radial aspect of the fingers This type of semi-opposition is found as late as 52 weeks. At 28 weeks complete thumb opposition makes a decisive appearance, increasing in frequency with each succeeding age up to 44 weeks Thereafter complete opposition is displayed almost universally in all grasping

The course of development of thumb opposition in grasping the rod differs somewhat from that of grasping the ball or cube The greater length and smaller diameter of the rod forces the thumb to assume postures which do not appear in the grasp of objects whose dimensions are more uniform. In early grasping of the rod, the thumb often adducts to a position closely in line with the metacarpal of the forefinger, which places the thumb behind the rod with the fingers Hence our larger classification has the thumb behind or in front of the rod. If the thumb is *behind the rod*, it either flexes into the palm with the rod or rests on the radial aspect of the forefinger or medius. The thumb *in front of the rod* may assume one of six postures. It may extend abductively upward, parallel with the rod, sometimes resting against the rod; the thumb may be flexed inside the palm with the rod; it may rest on the forefinger or medius; it may flex downward across the tips of the closed fingers, it may partially adduct and partially oppose the gripping fingers; or it may flatly oppose them Table 3 shows that after 28 weeks the thumb is no longer found behind the rod Proximity to the forefinger is a characteristic of early infancy

Permanent proximity would prevent the thumb from assuming a useful rôle in prehension The thumb divorces itself from the forefinger in order that it may better cooperate with it The volar surfaces of the digits are the object-contacting parts of the hand. In order that all of the mobile parts may better apply themselves to objects which they seek to prehend, it is necessary for at least one digit to square off and present its volar surface in opposition to the others The thumb alone is equipped to perform this function From 24 weeks on it gradually takes upon itself the office of meeting the flexing force of the fingers by a counter-balancing force so that the object may be held to best advantage To reach this degree of perfection, the thumb has to pass through successive developmental stages of pivoting until, depending on the spatial qualities of the object, it can fully meet the oppositional contingencies which arise in

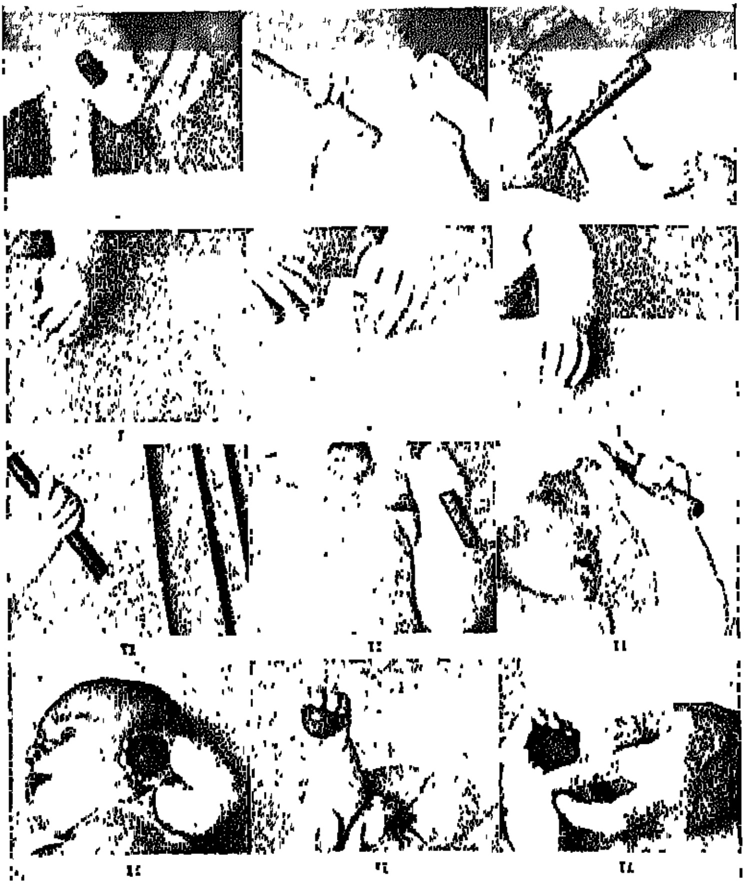

FIGURE 3

TYPICAL THUMB POSTURES EARLY STAGES

Two general types of prehensory posture mainly characteristic of the first half year of infancy are depicted I *Pre-pivotal adduction*, II *Pivoted adduction*

any specific prehensory act Examples of thumb posture in which partial opposition occurs appear from 20 to 52 weeks, even though opposition—in the case of the rod—is well developed at 36 weeks In the case of the ball and cube, full opposition is not generally used

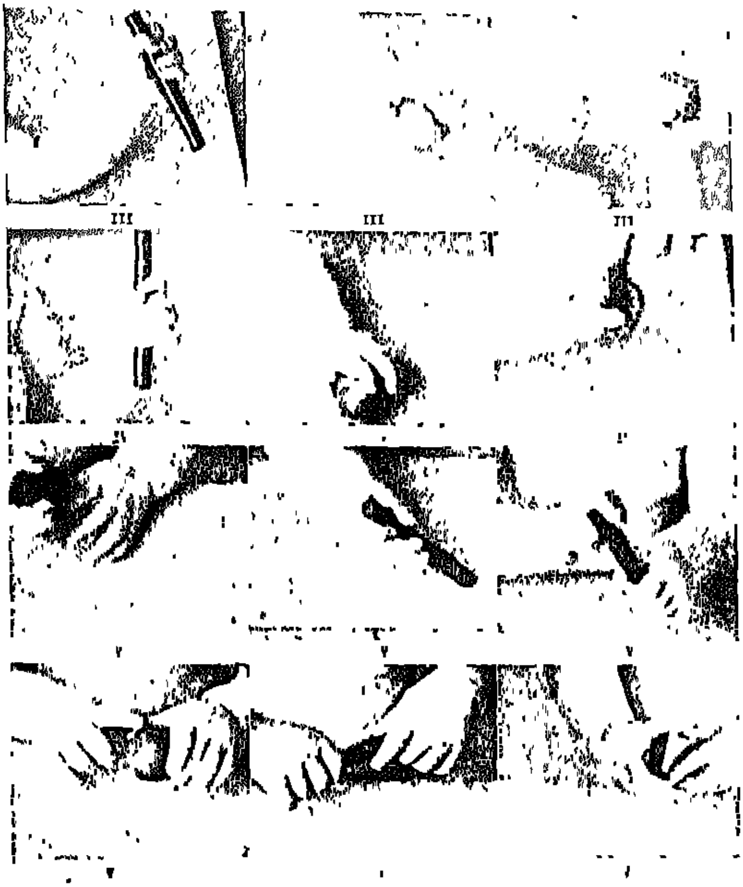

FIGURE 4

Typical Thumb Postures, Later Stages

Two general types of prehensory posture mainly characteristic of the last half of the first year are depicted III *Mesial opposition*, IV *Mesio-volar opposition*, V *Volar opposition*

until 44 weeks. The apparent discrepancy is due principally to the relatively great diameter of the latter objects which means that the thumb must pivot in a greater arc to circumscribe the object to the point where opposition is best attained.

Now when the fingers which are actively engaged in holding the object are considered, a larger number of peculiar finger combinations are found to occur with the rod than with the other objects In general, the ulnar fingers play a prominent rôle in early grasping while the radial fingers assume increasing importance in later grasping In the case of the rod, the use of all fingers is common at all ages because its relatively great length makes holding by two or three fingers precarious. While instances of the use of all the fingers are found at all ages in the case of the cube, there is diminution in the frequency of their use The increase in the use of the radial fingers, 2, 3, and 4, from 32 weeks to 52 weeks, moreover, shows that while the ulnar fingers are applied to objects, they play a subordinate rôle in the grasping activity.

Illustrations of the five developmental postures of the thumb on the ball, as indicated in Table 2, are shown in Figures 3 and 4 The eight thumb postures with the rod, which are differentiated in Table 3, are also pictured in Figures 3 and 4.

VI The Ulnar-Radial Shift

In the ontogenesis of prehension there is not only a proximal-distal trend but there is an ulnar-radial shift This shift is closely bound up with the specific act of thumb opposition

We have already mentioned a simple procedure by which the evidence of ulnar or radial preference was elicited and recorded by cinema Among other objects a ball was inserted first in the ulnar and then in the radial region of the palm. This test brought out interesting differential responses which are summarized in the table below

The table below shows an increasing preference for radial as opposed to ulnar tactile stimulation. The preference is especially marked after 28 weeks The developmental shift from ulnar to radial grasp is so strong that the infant often displays a well-defined intolerance, as well as a motor rejection, of the ulnar insertion even though such insertion was quite acceptable to him at earlier age levels. His resistance is emotionally colored

In the grasp reflex which is so prominent in the neonatal period it is the ulnar side of the hand which chiefly functions The motor

TABLE 4

Differential Responses to a Ball when Presented in the Ulnar and the Radial Aspects of the Palm

Age in wks	Ulnar insertion				Radial insertion			
	Accepts readily	Accepts delay	Resists	Rejects	Accepts readily	Accepts delay	Resists	Rejects
8			1				1	
12	2				1			
16	6				3	1	2	
20	2	2		1	1	2	1	
24	3	1		1	4			
28	3		2		6			
32			2	1	6			
36			1	1	6			
44			1		6			
52			2		6			

enervation of the ulnar digits is immature. The grasp reflex is probably mediated by subcortical centers. With the growth of the intrinsic musculature of the hand this grasp response wanes; ulnar flexion and thumb opposition make their appearance, increasing steadily with the progressive maturation of the neural structures which penetrate the tendons and muscle systems of Digits I and II. Somewhat figuratively this whole process of ulnar organization may be described as one of gradual "emancipation."

In early infancy up to eight weeks, the digits characteristically are closely flexed. At 12 and 16 weeks Swan found some "individuation" of thumb, forefinger, and little finger, manifested in increasingly prolonged extension and semi-extension.

> The individuation of the digits followed a temporal pattern . . . The index individuated first at 4 weeks, and showed a gradual increase in differentiation through 16 weeks, after which time differentiation became more rapid so that by 24 weeks the index remained semi-extended 95 per cent of the time. The thumb began to individuate at about eight weeks. It showed a slower, more gradual emancipation. . . (9)

This individuation, noted in the quiescent hand, is simply one aspect of a complex but integrated developmental process which embraces both the gross and the refined components of postural adjustment.

The whole process is a gradual one which indeed begins *in utero*, but 28 weeks may be regarded as the critical age when the vertical attitude of the hand prior to grasp begins to give way to a horizontal orientation and a correlated predominance of the radial digits.

The vertical attitude of the prehending hand may be thought of as a persisting residual of the closing-in type of approach which is so characteristic of both the supine and the sedentary infant at 16 and at 20 weeks Such "closing in," when bilateral, results in opposition of the palms. The horizontal attitude in approach is correlated with unilaterality and is a natural condition of elementary thumb opposition. As the thumb opposition becomes more advanced, the rotation of the plane of the palm continues and the palm assumes an oblique, everted attitude still further removed from its more primitive orientation. This tilting of the hand just prior to fine grasping is part and parcel of the function of thumb opposition.

VIII. TYPES AND DEGREES OF THUMB OPPOSITION

The criterion of perfect thumb opposition is the capacity to bring the volar pad of the thumb completely against the corresponding pad of every other digit. Such "perfect" opposition is often lacking even in the adult who usually succeeds in bringing the thumb pad against only the mesial aspect of the volar pad of the minimus. The system of levers in his hand is too inflexible to permit full approximation. This difficulty suggests that the infant comes by the power of thumb opposition by gradual degrees.

And such is the case. This accounts for the varying ages assigned by different writers to the appearance of thumb opposition. Thumb opposition does not emerge suddenly, must be described in relative terms, and assumes specific variations adapted to the form and dimensions of the object grasped.

Accordingly we find that "the rate of development," that is the frequency of thumb opposition, is different for rigid than for nonrigid objects At all age levels from 24 through 56 weeks, the percentage of occurrences of opposition grasp was much less for the string than for the ball, cube, or rod. The accompanying graph (Figure 5) summarizes the differences. From 24 to 28 weeks the frequency of thumb opposition in grasp of ball, cube, and rod is about twice that observed in prehension of the string In fact,

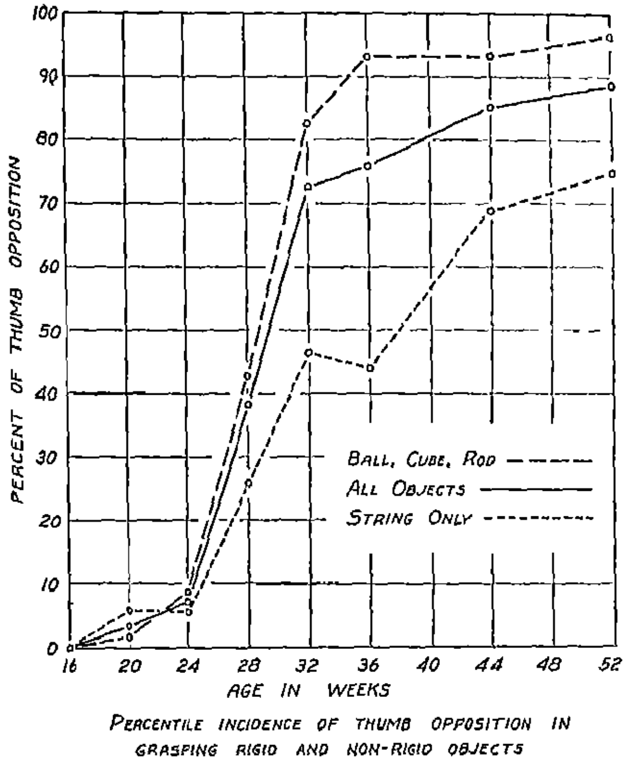

FIGURE 5

Percentile Incidence of Thumb Opposition in Grasping Rigid and Non-Rigid Objects

thumb opposition is farther advanced for rigid objects at 32 weeks than for the string at 52 weeks.

For similar reasons the manifestation of thumb opposition varies with the size of the object, and also with the relative position of the object just prior to grasp. It will be desirable, therefore, to classify the degree and mode of opposition in terms of a standard object like a cube, or ball, of stated size.

Thumb opposition proved to be not a hard and fast pattern, but a variable mode of prehensory adaption. Ordinarily the thumb is

TABLE 5

THUMB POSTURES IN RELATION TO BALL, CUBE, ROD, AND STRING

Age in wks	Ball			Cube			Rod			String		
	Adduction	Partial opposition	Opposition	Adduction	Partial opposition	Opposition	Adduction	Partial opposition	Opposition	Adduction	Partial opposition	Opposition
4	2						2					
8	2			2			2					
12	6			4			5			2		
16	14			16	1		15			13		
20	15			17			14	1		16		1
24	10	2		12	5		9	4		13	1	1
28	10	4	5	8	1	6	6	6	6	14		5
32	4	2	7	2	2	9	4	5	9	9	2	10
36	1	2	13	3	1	9		1	17	12	3	12
44	1		15			18	2		16	8		18
52	1		16		2	13	1	2	15	5	1	18

circum-adducted in the direction of the index; however, the index may also be brought against or toward the thumb, and each may flex independently of the other

In a preliminary phase of our study we adopted a simple classification of thumb postures and confined the discussion mainly to objects of standard shape and size, namely, ball, cube, and rod. These objects were presented in accordance with standard procedures elsewhere described. For these objects there is considerable regularity in the frequency of three types of thumb posture, namely.

1. *Simple adduction* of the thumb.
2 *Partial opposition* in which the thumb partly adducts, partly opposes, the volar pad is marginally or mesially applied against the presenting surface of the object.
3 *Opposition* in which the volar pad is squarely applied to the presenting surface of the object.

Cinematically observed, the classification of any individual thumb posture can be made without difficulty

The accompanying table (Table 5) distributes the thumb postures on the basis of three categories, as observed in grasping the ball, cube, and rod at lunar month intervals throughout the first year of life To permit comparison, the last column carries figures for grasp of the string in both horizontal and vertical alignment

The frequencies of thumb postures expressed in combined percentages for ball, cube, and rod are tabulated below (Table 6)

The digital reactions to ball, cube, and rod furnish the best clue to the ontogenesis of thumb opposition The percentage frequencies

TABLE 6

COMBINED INCIDENCE OF THUMB REACTIONS TO BALL, CUBE, AND ROD
(Both absolute and percentage incidence indicated)

	Age in weeks							
Thumb posture	16	20	24	28	32	36	44	52
(*a*) Adduction or abduction	45	46	31	24	10	4	3	2
	98%	98%	75%	46%	23%	8 5%	6%	4%
(*b*) Partial adduction and partial opposition	1	1	11	11	9	4	0	4
	2%	2%	25%	21%	20%	8 5%	—	8%
(*c*) Full opposition	—	—	—	17	25	39	49	44
	—	—	—	33%	57%	83%	94%	98%

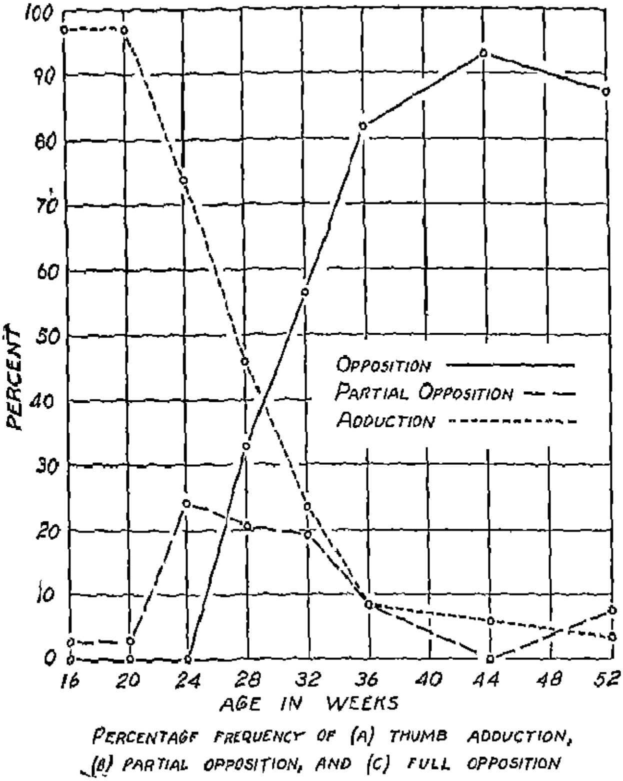

FIGURE 6
PERCENTAGE FREQUENCY OF (*a*) THUMB ADDUCTION, (*b*) PARTIAL OPPOSITION, AND (*c*) FULL OPPOSITION

of the three major modes of prehension (*a*) thumb adduction, (*b*) partial opposition, and (*c*) full opposition are plotted in the accompanying graph (Figure 6). This graph summarizes the significant developmental trends. It clearly shows that the age zone from 24 weeks through 32 weeks is the transitional period when thumb opposition is becoming established Prior to 20 weeks not a single instance of true thumb opposition was found; at 24 weeks there is no full thumb opposition but 28 per cent of the grasps show partial opposition. Adduction is really universal up to 20 weeks and persists in almost half the cases at 28 weeks. Partial opposition attains its maximum frequency at 24 weeks and there are instances of its occurrence as late as 52 weeks. Twenty-eight weeks marks the developmental turning point, for at that age adduction and opposition occur with almost equal frequency. At 36 weeks 82 per cent of the infants showed thumb opposition. The degree and the deftness of opposability continue to increase throughout the first year of life.

IX. General Conclusions

1 The course of development of the functioning of the thumb in grasping is from simple adduction, in which the digit parallels the metacarpals of the forefinger, to opposition, in which the thumb pivots to bring its distal volar pad to bear directly on the volar aspect of the other fingers.

2 This development is closely correlated with a general shift of functional predominance in which the radial digits replace the ulnar in grasping.

3. This developmental shift operates to the advantage of thumb opposition because the digits which most easily function in this type of grasping are the radial fingers.

4. In adduction the thumb may assume one of several postures, depending largely on the form of the object and on the position of the object in hand.

5. The form (and size) of the object to a large extent determines specific thumb postures. Nevertheless, the function of thumb opposition consists in bringing into approximation the planes of the volar pads. This is the criterion for true opposition.

6. The typical developmental progression in the attainment and perfection of thumb opposition can be outlined in the following categories which are illustrated in the accompanying photographs (Figures 3 and 4):

I. *Pre-pivotal adduction* (approximate age range 0-16 weeks). A slight degree of adduction in which the thumb closely corresponds to that of the metacarpus of the conjoint digits.

II *Pivoted adduction* (approximate age range 16-28 weeks)

The thumb now diverges from the conjoint metacarpus with a widening of the thenar crotch. A nascent stage of circumduction, dependent on the carpo-metacarpal articulation, which undergoes progressive topographic changes throughout infancy.

III. *Mesial opposition* (approximate age range 16-28 weeks). A slight degree of circumduction in which the thumb opposes by its mesial aspect.

IV *Mesio-volar opposition* (approximate age range 24-36 weeks). By more advanced circumduction the opposing thumb presents partly a mesial and partly a volar aspect

V. *Volar opposition* (approximate age range 32-52 weeks). Complete circumduction in which the volar aspect of the thumb is brought into full counteraction against an object or against an opposing volar pad.

The infant does not adopt any single method of prehension to the exclusion of other methods, and the age zones in which the five foregoing categories are displayed overlap. Nevertheless, there is a central developmental trend which is reflected in these sequences derived from an analysis of systematic cinema records

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The Yale Clinic of Child Development
New Haven, Connecticut

A CHIMPANZEE FAMILY*[1]

From Yale Laboratories of Primate Biology

ROBERT M. YERKES

Knowledge of the chimpanzee family in freedom is meager and of little value to the student of social behavior The observations now to be reported and the literature cited refer exclusively to captive individuals. Since its establishment in 1930 the breeding colony of chimpanzees maintained by Yale University at Orange Park, Florida, has offered increasingly varied and favorable opportunities for the study of social phenomena In the early years of the colony pregnant females were isolated, with intent to minimize the risk of reproductive accidents. But after the possibility of normal reproduction had been sufficiently demonstrated and several infants made available for immediate local use, certain social experiments were arranged. Of these, the first type is the association of two pregnant females, the second, an association of consorts which later became parents and infant

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[1] Acknowledgment is made of the assistance of the Committee for Research in Problems of Sex, National Research Council

This is one of a series of preliminary reports on such forms or aspects of social behavior in chimpanzee as grooming, suggestibility, avoidance, and sexual, parental, and familial relations The studies are avowedly exploratory and preparatory to an attempt to apply experimental method to problems of primate social life. The following papers have appeared or are in press.

BINGHAM, HAROLD C. Parental play of chimpanzees *J. Mammal*, 1927, **8**, 77-89.

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YERKES, ROBERT M., & YERKES, ADA W Nature and conditions of avoidance (fear) response in chimpanzee *J Comp. Psychol.*, 1936, **21**, 53-56.

SPENCE, KENNETH W Response of chimpanzee mothers to infants following separation *J Psychol* (in press)

Our mature females Wendy and Josie, and subsequently their infants, constituted the first experimental group in our approach to the study of familial relations. They were known to be intimately acquainted and friendly When placed together in quarters for this particular experiment Wendy was in her first pregnancy, Josie in her second, having previously suffered a miscarriage in the seventh lunar month.[2] Wendy and Josie were wholly peaceable and congenial throughout their period of companionship, although Wendy tended to dominate Josie and would compel her to surrender food on occasion Wendy's baby was born about three weeks before Josie's. So far as appears from our records, neither reproductive processes nor infant care were unfavorably affected by the social environment. The mothers cared each for her own infant during the latter's period of helplessness and each resented and thwarted any attempt on the part of the other to touch or in any way to minister to her infant. From the first, proprietary rights were recognized and as a rule respected. Neither during parturition nor subsequently did evidence of interference or undesired and unsolicited mutual aid appear After the infants, both of which were males, had achieved a considerable degree of independence of their mothers and were able to climb and run about freely and skillfully, social relations in the group became more complex and less stable. Disagreements began to appear. The first quarrel to be recorded which involved all four individuals was observed by Doctors Spence and Spragg when the infants were nearly a year old As briefly reported, the two babies became rough in their play and presently began to fight. One of them screamed. Instantly their mothers rushed to them, took their respective infants, and exchanged several blows The mêlée was lively but of short duration, and although excitement was intense no one was visibly injured.

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[2] For some weeks prior to impregnation these two females had been caged with another female, Mimi, and the mature male Bill This group was entirely harmonious Wendy and Josie were continued together, with two brief interruptions, through the gestational period, parturition, and until their infants had been taken from them for weaning at about one year of age Von Allesch (Bericht uber die drei ersten Lebensmonate eines Schimpansen, Sitzber. preuss Akad Wiss Berlin, 1921, p. 679 ff) has described the behavior of a group of chimpanzees in the Berlin Zoological Garden which included a mother and infant

There is no reason to infer from our data that infant growth and development proceeded less advantageously because of the presence of a second mother and infant. On the contrary it would appear that the welfare of all members of the social group was enhanced by the increased diversion and recreation which resulted from social stimulation. In our opinion the social environment was the more nearly natural, normal, and functionally adequate by reason of the presence of the additional female and her infant

Our second experiment consisted in leaving the male consort with his female following impregnation and throughout gestation, parturition, and the first fifteen weeks of infant-nursing This family group eventually was constituted by the male Pan, the female Nana, and their male infant Don.

Pan (*Pan satyrus satyrus*),[3] an exceptionally robust and energetic male, has been used experimentally in these laboratories for ten years. He is stocky, of medium size, with dark brown skin and rusty brown to gray hair. His hypothetical birth-date is 1922, his source the Cameroons. Although rated as relatively dull he is very good tempered, friendly, cooperative, and dependable

Nana (*Pan satyrus verus*) was brought to the colony in 1930 from French Guinea. Her hypothetical birth-date is 1921. Physically and behaviorally she differs extremely from Pan, for she is relatively small, slender, jet black as to skin and coat, shy, timid, gentle, and affectionate.

Early in their acquaintance (1930) Pan occasionally was rough in his treatment of Nana when they were temporarily brought together for mating. Probably sexual excitement and the strangeness of the female were responsible for this behavior Nana never tried to defend herself. Subsequently, after they had been caged near one another and had several times been together, the pair became friendly and they now (1935) are obviously affectively attached to one another.

Following impregnation of Nana by Pan in September, 1933, it seemed wholly safe to leave them together throughout the reproductive process in order that we might observe especially the behavior of the male as member of the family group This was Nana's second pregnancy, her first infant having been born on September 21, 1932, and separated from her for experimental use in June, 1933. Immediately thereafter she was placed in the cage with Pan and left with him.

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[3] According to Schwarz, *Ann. Mag Natural History*, 1934, **13**, p. 576.

The relations of these consorts continued to be amicable throughout the period of the experiment. Mutual grooming, which ordinarily indicates congeniality, was frequently observed. On August 5, 1933, Doctor James H. Elder of the staff recorded in our life-history files: "Pan and Nana are certainly the most affectionate pair of adult chimpanzees I have observed. It is seldom that one comes to greet an attendant without the other. This morning, when making observations of sexual status, I found them lying on the floor grooming each other. My calls did not disturb them for some time. When Nana finally arose Pan grasped her gently with a foot and began to clean her eyes and face." The writer with increasing frequency in the past three years has observed in this pair behavior clearly indicative of mutual attachment and considerateness.

Copulation was not observed during the gestational period. This is not an assertion that it never occurred, although that is the presumption. In this respect our observations contradict those reported by Montané, Tinklepaugh, and Schultz and Snyder.[4] Quite evidently the sexual relationship is variable, presumably due chiefly to the characteristics of the male, his age and developmental status, and the degree of familiarity and the strength of the social bond between the consorts.

Parturition, which was not observed, is known to have occurred about eight o'clock the morning of May 2, 1934. At the time the consorts were together in their small shelter room. When a few minutes later they were admitted by an attendant to the adjoining open-air cage the infant Don was discovered. At 8:20 A.M., father, mother, and infant were carefully observed in the cage, and thereafter during the day verbal and photographic records of their social

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[4] MONTANÉ, LOUIS. Un chimpancé Cubano. *El Siglo*, Havana, 1915, **20**, p. 11.

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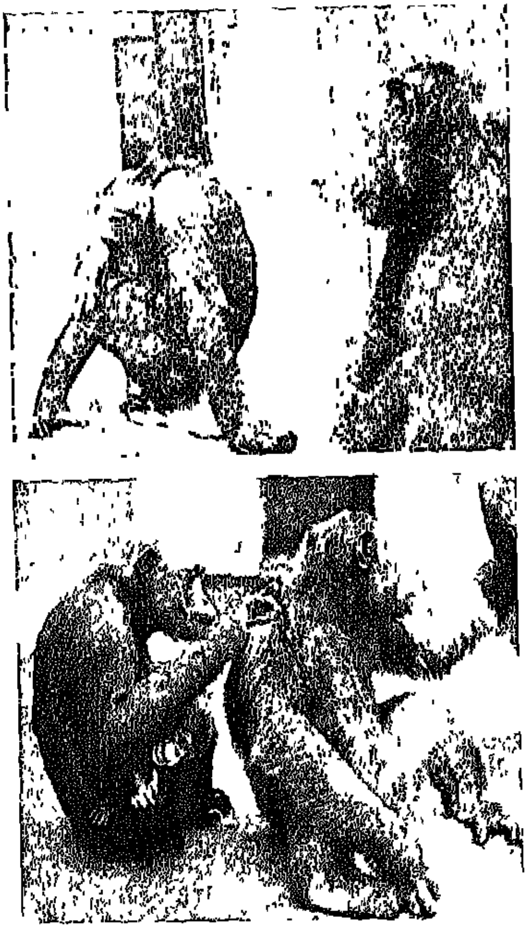

FIGURE 1

Upper

Pan (right) and Nana, with infant Don clinging to her, shortly after his birth, May 2, 1934 She is cleaning him while Pan watches placidly. The umbilical cord is still present

Lower

The family (Pan, Nana, and Don) about six weeks after the birth of Don. Nana is grooming her consort behavior and relations were made at intervals. The photographic records, reproduced herewith, importantly supplement the following summary verbal description

When the trio was first observed the mother was intent on her care of infant and self, while the father was quiet, calm, and seemingly interested in the infant and in Nana's actions Upon the writer Pan's behavior at this time made vivid impression of placid, friendly interest He appeared ready and eager to help if opportunity offered, but even to us human observers it was entirely clear that Nana neither desired nor needed his assistance. We doubt that she would have tolerated it For some hours after the birth of Don, Pan was unusually quiet, and he was not observed to molest either mother or infant. On the basis of this favorable relationship, it was immediately decided to keep the three animals together in the hope of establishing a congenial and cooperative, if not also a natural, family group

On May 7 the group was moved from its restricted livingroom-cage quarters to a more spacious fenced open-air enclosure with a roofed shelter building and sleeping-box The writer on June 1, 1934, entered the following in the life-history records of the individuals: "Pan, Nana, and Don have been living together contentedly without disturbance in the Enclosure. Pan does not interfere with Nana and the baby. I have not happened to see him giving attention to Don. This is a convincing demonstration of the possibility of housing a family group of chimpanzees together. It opens the way for experimental studies in social behavior which heretofore have been impossible."

Nana, quite commonly in the ensuing weeks, avoided Pan as if in fear of him When called to the side of the Enclosure to be observed, fed, or petted, she would not approach if Pan did or if he was near at hand Much of the time she sat, with Don clinging to her, on the timbers of the shelter building in the shade of its roof That this behavior was due to the hostility of the male might naturally be inferred were it not for the following facts, which are well established by our observations

As a rule the female chimpanzee with young is suspicious and cautious, constantly protecting her charge from the aggression of other organisms, and also from exposure to direct sunlight. The male of the species is potentially very dangerous to the female with young, both before and after parturition,[5] and it has been discovered in these laboratories that the temperature-regulating mechanism of the infant chimpanzee for several weeks after birth is inadequate to protect it from the injurious effects of over-exposure to sunlight[6] If Nana had acted as if fearless of her consort and had ignored the sun, her infant probably would have been injured.

We are making our observations available at this time because there is a prevalent superstition, from which we have not been immune, that the male chimpanzee under the spatial limitations of captivity may, either by intent or inadvertently during spells of excitement, injure his pregnant consort or their infant. Consequently it has been common practice to isolate females known to be pregnant. We have scrutinized the few and meager accounts of births in captivity to discover whether support exists for this assumption of hostility on the part of the male. In not a single instance of the few known to us[7] where the male was present either just before or also during parturition is there indication that he in any way interfered with the birth process or disturbed either mother or infant thereafter. The suspicion that the chimpanzee as male parent may on occasion destroy his offspring at present lacks observational support That he is potentially dangerous, we already have asserted. In the future we shall in this establishment act in accordance with our experimental needs, leaving the consorts together when it is essential To be sure it is only reasonable to assume that the two animals shall in advance be known as intimately acquainted, wholly accustomed to being together, and friendly, for to bring relative strangers together, even though they had previously mated successfully, would be inexcusably rash, save as crucial experiment.

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[5] In certain important aspects these interpretative statements are supported by the observations of Bingham (*op cit*) on behavior of a chimpanzee family in Cuba which consisted of father, mother, and an infant in its second year

[6] JACOBSEN, CARLYLE F, JACOBSEN, MARION M, & YOSHIOKA, JOSEPH G Development of an infant chimpanzee during her first year. *Comp. Psychol Monog.*, 1932, **9**, 1, p. 22 ff

BRUHN, JOHN M., & HASLERUD, GEORGE M. Unpublished observations

[7] BLAIR, W. REID Notes on the birth of a chimpanzee *Bull. N Y Zool Soc.*, 1920, **23**, 104-111

FOX HERBERT The birth of two anthropoid apes. *J Mammal*, 1929, **10**, 37-51.

There is no evidence in our observations or in the literature that the father chimpanzee aids in the care of his offspring during the months of its dependence upon the mother. Later, however, and especially after the infant has achieved locomotor independence, the male parent may amuse, protect, and defend it as occasion arises.[8]

SUMMARY

The principal points in this naturalistic study of a captive chimpanzee family may thus be restated.

During early acquaintance of the consorts the male sometimes was rough and hostile toward his female; she, protective, timid, never defensive. Later mutual friendliness developed and the male was consistently gentle and considerate toward this particular female Finally, during the period of familial relations and subsequently, manifestations of affection and devotion, particularly by the male, were observed. Mutual grooming was common, as well as physical attentions which may be designated as petting.

Sexual intercourse was not observed during the gestational period, nor during lactation to the date of separation of mother and infant from the father. At this time, nearly four months after parturition, the female sexual cycle, with its characteristic features of menstrual bleeding, genital swelling, and ovulation, had not been reestablished.

The male was an interested, passive observer of the parturitional process and of the newly born infant He in no way interfered with, or aided in, maternal care, but instead was gentle, friendly, and cooperative toward the members of his family The mother was continuously protective of infant and self, trusting neither her consort nor human males who approached her and her charge. The male seemingly accepted this attitude as a matter of course and without sign of resentment. Familial relations, like the relations of the consorts prior to the birth of the infant, appeared to be favorable to the health and contentment of the parents and to the development of the infant. We eventually characterized them as natural and normal. It is our surmise that this particular family, save in its limitation to a single female and a single offspring, more nearly represents the typical familial relations of the species in freedom than does any other of the descriptions available in the literature.

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[8] See Bingham (*op. cit*) for confirmation

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THE FUNCTION OF JACOBSON'S ORGAN IN LIZARDS*

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Jacobson's organ, lying in the roof of the mouth of most terrestrial vertebrates, has been a structure of problematic functions for many years. In spite of recent studies on the structure of this organ in mammals, its function is still a matter of dispute (Lautenschlager, 4) On the other hand, recent experiments with snakes, where the organ is very well developed, have seemed to show clearly that its important function is in trail finding. It is well known that snakes frequently flicker their tongues in following a trail. Observations and experiments of Baumann (1) and Kahmann (2, 3) seem to show that the tongue on these occasions is thrust beyond the mouth for the purpose of picking up odors in the air The forked tips of the tongue carried back into the mouth are thrust upward into the ducts leading from the paired Jacobson's organ Minute particles of substances adhering to the tongue or dissolved in the saliva which keeps it moist are carried in this way directly to Jacobson's organ which may be considered an accessory organ of smell.

Kahmann (2, 3) made a few observations on lizards, which as a group may be considered more primitive than snakes and hence might be expected to show a less specialized behavior In many lizards the tongue is long, bifid, and is flickered in the manner of snakes while the animals move about It was in these forms that Kahmann assumed that Jacobson's organ had the same function as in snakes Unfortunately he has presented very little experimental evidence to support his thesis in this group. In view of the uncertainty as to the function of the organ in other groups of vertebrates it has seemed advisable to secure further information as to the function of the organ among the lizards which, although not directly ancestral to

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mammals, are at least nearer the main line of evolution than are the snakes

FEEDING REACTIONS OF LIZARDS

There are many lizards provided with a short, broad tongue which is rarely thrust out of the mouth during locomotion. Among these forms is the common fence lizard, *Sceloporus undulatus,* which according to our experience will feed only on living food visible to the animal. Other iguanids, such as *Leiocephalus inaguae,* may be readily trained to take a mixture of meat and eggs from dishes. However, we have never succeeded in inducing either of these iguanids to find food hidden under the gravel of their cages Seven trials with 88 *L inaguae* were run without a single success. Five tests with 50 blindfolded individuals of the same species also gave negative results. In striking contrast the teiid lizards available to us in series rarely failed in exactly the same tests. Pieces of cotton saturated with a solution of meat juice and egg were buried to a depth of approximately one centimeter below the floor gravel. Although *Leiocephalus* frequently buries itself in the gravel and invariably retires there in the evening if it is cool, none was attracted by the hidden baits. On the other hand, both *Ameiva exsul* and *Tupinambis nigropunctatus* were invariably successful if hungry and the conditions of light and temperature were adequate. These teiids, unlike the iguanids, have a long, bifid tongue which they frequently flicker. In view of the observations of Kahmann, it would be assumed that they were depending primarily on the tongue-Jacobson's organ mechanism in finding their food.

It may be noted, however, that these teiid lizards have the practice of constantly digging and scratching the gravel when hunting for food. Some buried food would be turned up accidentally during these operations It was not clear from daily observations what rôle the various sense organs played in food finding. We have therefore carried forward a series of experiments on both *Tupinambis nigropunctatus* and *Ameiva exsul* Only the latter, which were the more complete, need be reported here.

MATERIALS AND METHODS

In our experiments with *Ameiva exsul* we have restricted ourselves to a single series of individuals collected in the vicinity of Bayamon, Porto Rico The lizards were kept in cages measuring 40.5 x 63.5 x 49 cms., provided with glass sides, and a screen top. Clean gravel to a depth of 2 cms. covered the bottom of each cage. The lizards were never fed during the period of observation. Three to eight lizards were employed in each trial and these were repeated until over 50 individuals had been run through each type of experiment. The trials were made only on bright days Between certain temperature limits sunshine increases the activity of the lizards and hence the tests were made only on days when the controls exhibited an average activity. Each trial was limited to a two-hour period. If at the end of that time the lizards had failed to find the hidden food their performance was considered a failure.

The hidden bait consisted of two or three pieces of cotton, a centimeter in diameter, saturated with an extract of beef juice and egg, or with a mixture of tomato juice and cod-liver oil. In a few cases meal worms were employed as a supplementary bait. The series of lizards had been fed for several weeks previous to the experiment on an egg-meat diet supplemented once a week by the tomato juice and cod-liver oil and occassionally by meal worms. Hence the experiments were designed to test the ability of these lizards to find the food to which they had previously become accustomed.

The baits were buried under the gravel of the cage and entirely concealed from view. After each trial the position of the bait was changed in order to prevent learned motor habits from influencing the result. At frequent intervals the gravel was entirely replaced by fresh gravel in order to prevent food particles adhering to the gravel from modifying the results.

Eleven different types of operations were performed on the lizards before they were tested. In the simplest experiment the lizards were merely blindfolded by adjusting pieces of adhesive tape across the eyes and painting the tape with photographer's opaque Since the lizards were not tested until several days after blindfolding, it was found desirable to apply a thin coat of collodion over the opaque to prevent any loss of the paint through rubbing and to stick the tape more firmly to the head.

In the second series of tests the tongues were removed from a series of individuals. Several days after the operation, when the lizards were found to be normal in their movements, they were tested in their ability to find hidden bait

For the third series of tests, the two halves of the Jacobson's organ were removed by cauterizing. Forty-eight hours after this operation the lizards were found to be normal in their responses and were tested for the first time. Before testing, the roof of the mouth was examined under a binocular in order to make sure the organs had been entirely removed. After the tests, a series of individuals was killed, and the heads examined in serial sections. In all cases microscopic examination demonstrated that the organs had been entirely destroyed.

In the fourth series of tests, the external nares of a group of lizards were closed by thrusting plugs of cotton into them and then painting the plug with a ten per cent solution of collodion. Frequent examination of these cotton plugs was made in order to make sure they were tight throughout the series of trials.

Finally, a series of lizards was tested in which various combinations of sense organs were prevented from functioning. This group included first, a blindfolded and tongueless series, second, a blindfolded and nostril-plugged series, third, a tongueless and nostril-plugged series; fourth, a nostril-plugged and Jacobson's-organ-destroyed series, fifth, a blindfolded, a nostril-plugged, and tongueless series; sixth, a blindfolded, tongueless, Jacobson's-organ-destroyed series, seventh, a blindfolded, nostril-plugged, and Jacobson's-organ-destroyed series. All these lizards were tested in exactly the same manner as the control series of untreated lizards. A detailed record of the movements of the lizards during the test was made. The following represents a typical protocol

April 10, 1933

Tongueless and Blindfolded Series

5 *Ameiva exsul* having tongues removed and eyes blindfolded with adhesive tape and opaque

5 pieces of cotton (3 saturated with meat and egg extract, 2 of the same size untreated) buried under stones of the cage at 1 29 P.M.

1.31 The first piece of cotton with food extract is found. There is a deliberate approach to bait with nosing movements. An individual walks across the cage floor until it comes to spot where cotton is buried and then begins to dig. It does not completely uncover the bait but eats it with snout thrust into the gravel. Another lizard joins the first in eating the bait

1 34 The piece is completely exposed, and is removed from cage
1 36 The second piece is found in the same deliberate fashion and is removed by observer.
1 41 The third piece of bait is uncovered as a result of definitely directed digging Two lizards are after it and are eating parts of it among the stones Bait is removed by observer.
1 49 Experiment is closed since none of the untreated pieces of cotton has been found

Duration of observation· 20 minutes
Food found deliberately in 2 minutes, 7 minutes and 12 minutes
Untreated cotton remained undiscovered

It is obvious from such a record as the above that these lizards can find hidden food without the use of their tongues. In order to establish, however, the exact function of the olfactory and Jacobson's organs in the finding of hidden food, it was necessary to run through all the experiments listed above The results of these experiments have been presented in Table 1.

Examination of this table will show that Jacobson's organ is not essential in finding hidden food as Kahmann claimed in the case of snakes Removal of the tongue and destruction of Jacobson's organ do not prevent *A. exsul* from finding hidden food. From 70 to 80 per cent of the food was found during the two-hour period, while the control lizards with all their sensory mechanisms available to them were only ten per cent more successful It might be assumed that these controls would find 100 per cent of the food in the two-hour period but ten different tests on 67 animals showed conclusively that the area to be covered was too large for the lizards to find more than 90 per cent of the food in the two-hour period It might seem remarkable that when the lizards were blindfolded all of the food was found in the two-hour period and the average time to find the food was much shorter than in the controls Apparently the blindfolded lizards had become accustomed to the blindfolded condition and were very little distracted by the movements of other lizards They soon settled down to find the food by means of their chemical senses and hence made a better record than the controls which tended to be distracted by other activities in the cage.

The blindfolded, nose-plugged, and tongueless series (No 10) shows that the Jacobson's organ is incapable of helping the lizards find the hidden food without the aid of the tongue. To this extent our observations confirm the conclusions of Baumann and Kahmann. The blindfolded, nostril-plugged, and Jacobson's-organless series (No. 12) also shows that the tongue does not function as a distance receptor alone. Only when the Jacobson's organ is present can the tongue be used as an organ for detecting hidden food.

The table also shows that it is impossible to designate any single organ as the principal mechanism for finding hidden food. The blindfolded, tongueless, and Jacobson's-organless series (No. 11) did much better than the blindfolded, nostril-plugged, and tongueless series (No. 10). This might be taken as evidence that olfactory organs were of more importance than the Jacobson's organ in finding hidden food. The records show that lizards having both olfactory organs and Jacobson's organs available make much better scores than do lizards lacking either one of these organs. It is therefore evident that normally Jacobson's organ supplements the olfactory organs as a detector of hidden food. This conclusion is further substantiated by comparison of the lizards having the olfactory organs incapacitated (No. 7) with those having Jacobson's organs removed (No. 11).

THE RÔLE OF JACOBSON'S ORGAN IN THE BROODING HABIT

Jacobson's organ presumably has other sensory functions besides those of aiding in the detection of hidden food. We, however, have tested its value in only one other situation. Various groups of lizards brood their eggs. Noble and Mason (5) were able to show that American skinks of the genus *Eumeces* were able to distinguish their eggs from those of other lizards even when blindfolded. Their observations were, however, not carried far enough to prove conclusively the relative importance of tongue and Jacobson's organ in the identification of eggs. We have had one female *Eumeces laticeps* under observation. After egg laying this lizard was tested in very much the same manner as *Ameiva,* except that the floor of the cage was covered with decaying wood and the incentive was not bait but the lizard's own eggs. We were able to run a series of tests with the lizard blindfolded, nostrils plugged, and tongueless.

The brooding female was tested six times before incapacitating any of her sensory mechanisms In four of these cases she was merely frightened from the nest Each time she was observed to find her eggs and resume brooding. The shortest time required in returning to the eggs was 30 minutes, the longest 23 hours. Once her eggs were moved to another nest and two additional empty nests prepared to attract her if possible The second day she was found in one of the sham nests but within the next 24 hours she had discovered the eggs and was lying among them. In the second trial with the eggs moved to a new position in the cage and two additional nests provided she was found brooding again within 22 hours.

The female *E. laticeps* was then deprived of the use of her nostrils in the same manner as were the *Ameiva* She found her nest in four and one-half hours. She was then blindfolded in addition to having the nostrils plugged In each of six tests with eggs in new sites she resumed brooding activities In one case she required only ten minutes to find her eggs An additional experiment in which the eggs were moved to another nest was made after she had been blindfolded and had her nostrils plugged After five hours she was back among her eggs

Several trials were made after removing the female's tongue The seven eggs remaining in the clutch—some of them had been damaged and consequently removed—were divided into three nests of three, two, and two eggs respectively. At the end of 18 hours she was brooding the group of three and had left the others untouched This experiment was repeated and the second time she returned to the same three in 20 hours At the third trial she found the three in five and one-half hours.

At the conclusion of these tests all the eggs were moved to another site She found them and began brooding them on five different occasions and always within a seven-hour period Then the eggs were left in the same nest but arranged in various patterns of which a record was kept Nine times out of nine trials she found the eggs and rearranged them before brooding The shortest time required in this group was three hours The tongueless lizard was then moved to another cage and her eggs scattered over the floor An egg of *Sceloporus undulatus*, which resembles that of *E laticeps* closely, was added to the lot The female found the eggs, rearranged them and resumed brooding activities but did not include the *Scelo-*

porus egg in the nest. The latter egg was left by itself on top of the wood pulp and at a distance from the bark covering the nest This observation confirms the conclusion of Noble and Mason (5) that the brooding *E laticeps* can distinguish the eggs of *Sceloporus undulatus* from her own, but it extends these observations further in showing that the lizard is capable of doing so even when deprived of her tongue.

Unfortunately, it was not possible to remove the Jacobson's organs from this brooding female. The observations, as far as they go, entirely confirm our observations on *Ameiva.* Although Noble and Mason were able to show that the female would find her eggs when her nostrils were plugged, these experiments showed that the lizard can also find her eggs and distinguish them from those of *Sceloporus* when she is deprived of her tongue and is presumably using only her olfactory organs to find and distinguish them from the eggs of other species The tongue is apparently useful to the female *Eumeces* in finding her eggs but it is not indispensable, since the olfactory organs can also be used for this purpose. Thus, in both *Eumeces* and *Ameiva,* Jacobson's organ must be considered only an accessory mechanism for distinguishing odors Olfactory organs are presumably the chief organs for discrimination in both these groups of lizards.

CONCLUSIONS

Jacobson's organ functions as a distance receptor in lizards such as *Ameiva exsul* which are provided with a long bifid tongue Odorous substances are carried by the tongue directly to Jacobson's organ These lizards may, however, find hidden food by means of their olfactory organs alone Hence Jacobson's organ must be considered only an accessory organ of olfaction.

Lizards which brood their eggs may use their tongue-Jacobson's organ mechanism to find and to distinguish their eggs from those of other species. But here again the olfactory organs may function alone in egg finding and egg discrimination.

The tongue-Jacobson's organ mechanism is of decided advantage to lizards in supplementing the olfactory organs The period required to find hidden food is shorter when both the olfactory and the tongue-Jacobson's organ mechanism are functioning.

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LA FONCTION DE L'ORGANE DE JACOBSON CHEZ LES LÉZARDS

(Résumé)

L'organe de Jacobson fonctionne comme récepteur de distance chez les lézards tels qu'*Ameiva exsul* lesquels sont pourvus d'une longue langue bifide Les substances odorantes sont portées par la langue directement à l'organe de Jacobson Ces lézards peuvent trouver cependant de la nourriture cachée au moyen de leurs organes olfactifs seuls On doit donc considérer l'organe de Jacobson seulement comme un organe accessoire de l'olfaction.

Les lezards qui couvent leurs oeufs peuvent employer le mécanisme de la langue et de l'organe de Jacobson pour trouver et distinguer leurs oeufs de ceux d'autres espèces Mais ici encore les organes olfactifs peuvent fonctionner seuls dans le découverte et la discrimination des oeufs.

Le mécanisme de la langue et de l'organe de Jacobson est très avantageux pour les lézards comme supplément des organes olfactifs La période nécessaire pour trouver la nourriture cachée est plus courte quand le mécanisme olfactif et celui de la langue et de l'organe de Jacobson fonctionnent tous deux

NOBLE ET KUMPF

DIE FUNKTION DES JACOBSONSCHEN ORGANS BEI EIDECHSEN

(Referat)

Jacobsons Organ funktioniert als ein Entfernungsempfanger bei Eidechsen wie *Ameiva exsul*, die eine lange zweispitzige Zunge besitzen Duftende Substanzen werden durch die Zunge dem Jacobsonschen Organ unmittelbar uberliefert. Übrigens konnen diese Eidechsen Nahrung vermittelst ihrer

Geruchsorgane allein finden Folglich muss Jacobsons Organ nur als Nebenorgan des Geruchs angesehen werden.

Eidechsen, die ihre Eier bruten, gebrauchen ihr Jacobsons Organ, um ihre Eier von denjenigen anderer Gattungen zu unterscheiden Aber auch hier konnen die Geruchsorgane zur Auffindung und Unterscheidung der Eier allein funktionieren

Der Jacobson Zungenmechanismus ist von entschiedenem Vorteil zur Erganzung der Geruchsorgane Die Zeitdauer zur Auffindung verborgener Nahrung ist kurzer, wenn sowohl das Geruchs- als auch Jacogsons Zungenorgan funktionieren

NOBLE UND KUMPF

"MATURATION" VS "LEARNING" IN THE DEVELOPMENT OF VESTIBULAR AND OPTOKINETIC NYSTAGMUS*[1]

From the Psychology Laboratory of Princeton University

O. H. MOWRER[2]

I. THE DEVELOPMENT OF VESTIBULAR NYSTAGMUS

It has repeatedly been noted that there are certain characteristic differences between the vestibular nystagmus which is elicited in newborn vertebrates by a period of continuous bodily rotation and the nystagmus which is elicited by comparable stimulation in adult organisms. Observations on cats (10, 16, 21, 32), rabbits (21), dogs (12, 21), guinea-pigs (6, 21), pigeons (33), and human beings (1, 3, 4, 12, 16, 29) have been reported in this connection and consistently show that post-rotational nystagmus in the very young of these species—if it occurs at all—is much briefer, weaker, and less well coordinated than at later stages of development.

In so far as the writers cited have expressed an opinion, they seem to be generally agreed with Prince (32) that these post-natal developmental changes "are explained by a relatively late myelination of the nervous paths concerned" or by some other feature of neural growth. There are, however, certain considerations which throw some doubt upon the validity of this assumption. It is well established that the vestibular receptors and their afferent nerves are among the first sensory mechanisms to become capable of function during embryonic life (31, 34); the lag in the development of vestibular nystagmus cannot, therefore, be attributed to any structural deficit on the sensory side of the reaction mechanism.

The observations of Fish and Windle (10) that the postnatal development of vestibular nystagmus in kittens appears to be directly

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[1] This investigation was undertaken by the writer while a National Research Fellow at Northwestern University (1932-33) and was completed at Princeton University (1933-34), in the same capacity.

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related to the visual experience of the growing organisms strongly suggests that a learning process is here involved To quote:

> . . . It is possible that the artificial opening of the eyes of the kittens in the present series may have had an influence on the time of appearance of the ocular movements In a number of cases the eyelids were separated at the time of birth or on the first or second day thereafter, and, correlated with this, the appearance of postrotatory deviation and nystagmus seemed to be precocious.

It is a matter of common agreement that the primary if not exclusive biological function of the vestibulo-ocular reflexes involved in vestibular nystagmus is the facilitation of efficient visual fixation during rotary movements of the head or of the entire body (23). The suggestion of Fish and Windle that vision may influence the development of these reflexes seems, therefore, quite plausible

It is also generally acknowledged that normal conjugate movement of the eyes represents one of the most complex and nicely adjusted reactions which living organisms are capable of making (8) In view of this fact, Lorente de Nó (20) has raised the question whether *any* such complex reaction can be entirely the expression of what might be loosely called the "blind forces of maturation." This writer points out the striking individual variations in the size of the various extrinsic eye muscles, in the richness of the innervation of these muscles, and in the shape and size of the vestibular receptors, and emphasizes the great improbability that these diverse factors could be so integrated and balanced by means of strictly hereditary determiners[3] as to bring about, independently of learning, the observed reactions. On the basis of these reflections, Lorente de Nó comes to the conclusion that the vestibulo-ocular reflexes must be "partly inborn and partly learned," the visual experience of the growing organism being, presumably, the dominant factor in bringing about the ultimate refinement of control and the perfect synergy which characterize these reactions.

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[3] By "strictly hereditary determiners" the writer means the chemical constituents and organization of the fertilized egg *plus* the so-called "field factors" [cf Burr, (5)] which arise from the chemical and electrical interaction of the egg and its embryonic environment as opposed to the modification of behavior by previous behavior [cf Guthrie, (14)] which is ordinarily termed "learning"

According to the theory of development elaborated by Holt (15), *all* muscular reactions (except "*random* writhings, wriggling, and twitchings") originate through learning of one kind or another. If this thesis is valid it should be possible, by appropriately controlling the sensory experience of growing organisms, to prevent the development of any given type of reaction. For reasons already indicated, the development of vestibular nystagmus might be expected, on the basis of Holt's theory, to be specifically dependent upon vision. That this, however, is not true as regards at least the early phases of the development of this reaction is indicated by the fact that the young of virtually all vertebrates show as soon as born (or hatched) a definite drift of the eyes (or entire head) in response to vestibular stimulation. If this response has developed through learning, rather than through the maturation of inherited neural patterns, it is obvious that visual stimulation has had no part in the process Whether visual stimulation plays a significant rôle in the *postnatal* transformation of these early vestibular reactions into true nystagmus (consisting of alternating slow and quick phases) is a point on which previous evidence has not been conclusive.

As mentioned above, the observations of Fish and Windle (10) suggest that in kittens vision does play an important part in the development of vestibular nystagmus. On the other hand, Nasiell (30) found that two rabbits which had been born and reared in complete darkness to the age of three weeks "show after rotation around the vertical, sagittal, and frontal axes normal types of nystagmus (normalen Nystagmusarten)." However, in making these observations Nasiell was primarily interested in determining merely whether these animals would develop a spontaneous nystagmus, or so-called "nystagmus of the blind," as a consequence of being deprived of normal visual experience, and his observations on the nystagmus produced by vestibular stimulation were quite incidental and do not purport to constitute a careful quantitative comparison of the vestibular nystagmus of animals reared with normal visual experience and that of animals reared without visual experience.

In view, therefore, of the sparsity and inconsistency of the available evidence, it seemed important to submit this problem to a rigorous and extended experimental examination. As subjects for such a study pigeons seemed to offer numerous advantages In the first place, they show a nystagmus of the entire head, which is much easier to record than is eye nystagmus They attain approximately adult size in four or five weeks and can easily be reared under laboratory conditions. Finally, the young are abundantly fed through regurgitation by the parent birds and are therefore not necessarily dependent upon vision in obtaining food

Ocular enucleation was considered as a possible method of eliminating vision but was not resorted to because of the necessarily permanent loss of vision and because of the danger of infection. Rearing the birds in a totally dark room would have offered an ideal solution to the problem had it not been for the practical difficulty of inducing adult pigeons to breed and nest in complete darkness. And since squabs are dependent upon the predigested food normally received from the parents, it was not possible to hatch and feed them artificially Fortunately for the purposes of the present experiment, the pigeon possesses a well-developed and functionally active nictitating membrane (24), or "third eyelid," which keeps the cornea well lubricated and free from irritation even though the two external eyelids be snugly sutured together In view of these considerations, the eyelid suture technique was adopted as the means of depriving the squabs of normal vision

In all, ten squabs, which were hatched from eggs laid and incubated by homing pigeons, were reared to five weeks of age, with vision excluded by the method indicated Since the eyelids of squabs do not normally open until the third or fourth day after hatching, two days were usually allowed to elapse before the first stitch was taken From then on other stitches were added as they became necessary, due to the growth of the lids Four to six stitches usually sufficed The squabs thus blinded were weighed from time to time in order to make sure that they were being properly nourished, but at no stage of development did their weights differ materially from those of a group of ten squabs which were reared, with normal vision, as controls The responses involved in the reception of the food regurgitated by the parents were in no way defective in the blinded birds, and, surprisingly enough, during the fourth and fifth weeks these squabs were frequently observed pecking grain, in a groping, awkward fashion, from the pan from which the parents were fed.[4] That this latter performance might have been dependent upon visual cues seems most improbable. Careful observation revealed that in the beginning the blinded squabs often pecked aimlessly in the air or at the bare floor or sides of their cage (about 18 inches square) Moreover, it was found that the squabs made no observable response either to moving shadows cast by a bright light or to any other type of visual stimulus Some light undoubtedly penetrated through the eyelids, but it was so diffuse and of such low intensity that it could scarcely have been of any importance in localizing food or in the establishing of any other specific visual habit

Although the general level of activity in the blinded birds was definitely lower than in the normal controls, they nevertheless learned to walk in a manner that was perfectly normal except for the fact that they held the head stiffly extended in the forward direction instead of bobbing it backwards and forwards as birds with vision ordinarily do (9). During the fourth and fifth weeks they engaged in the same type of fluttering of the wings as normal birds and even learned to lift themselves an inch or so off the floor When tossed into the air they usually came to the floor without mishap, but they never attempted real flight. So far as could be observed, they were entirely unable to avoid obstacles either when walking or when forced to fly by being tossed into the air. In short, there was no evidence whatever that they ever made either specific or general reactions to visual stimulation of any kind.

At five weeks of age each of the ten blinded squabs was tested on three successive days for post-rotational vestibular nystagmus, the rotation consisting of 20 counterclockwise turns in 30 seconds, with acceleration and retardation each occupying less than two seconds. At the same age, each of the ten normal birds was subjected to exactly the same procedure Both the blinded and the normal birds were immobilized by a cloth wrapper and allowed to remain unmolested in a quiet room for 20 minutes before they were rotated, the heads of all birds being covered with a snug cloth hood Observations reported elsewhere (26) have indicated that when normal pigeons are rotated immediately after being caught and hooded, their post-rotational nystagmus lasts, on the average, about 30 per cent longer than when they are first subjected to a "quiet period" of the kind just described. Since the birds with the sutured eyelids were permanently in very much the same condition as normal birds during the "quiet period," the precaution of subjecting both groups of squabs to as nearly identical conditions as possible for some time preceding the rotation seemed very essential.

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[4] Later observations have shown that squabs reared without vision learn not only to feed themselves but also to locate and drink water alone and are capable of independent survival after being separated from the parent birds, providing that food and water are easily accessible

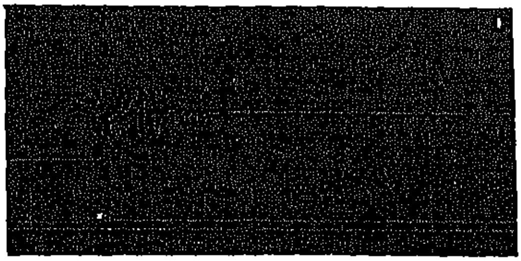
From the numerical values presented in Table 1, it is evident that

TABLE 1

The entries in this table represent the duration (in seconds) of the post-rotational vestibular nystagmus of two groups of squabs which were tested on three successive days at six weeks of age. The ten birds constituting the experimental group were reared with vision excluded by means of suturing their eyelids together; the ten members of the control group were reared with normal vision As the table shows, there was no significant difference in the average duration of nystagmus in the two groups

	Experimental group				Control group		
Subject	1st test	2nd test	3rd test	Subject	1st test	2nd test	3rd test
1E	25.2	18.6	15.0	1C	16.0	11.8	14.4
2E	19.2	20.4	18.5	2C	15.2	18.6	14.7
3E	25.9	15.1	21.8	3C	20.4	18.4	19.0
4E	17.4	16.0	15.6	4C	20.6	14.8	17.8
5E	16.4	14.4	16.5	5C	13.1	17.9	15.2
6E	16.1	13.2	14.7	6C	14.2	18.1	11.5
7E	14.4	14.9	16.9	7C	21.6	22.2	20.8
8E	12.8	12.3	11.2	8C	18.0	11.8	12.0
9E	18.9	18.7	17.6	9C	19.9	13.6	9.5
10E	14.9	16.3	13.8	10C	17.1	18.2	18.0
Average	18.12	15.99	16.16	Average	17.61	16.54	15.29

there was no significant difference in the average duration of the nystagmic responses shown by the blinded and by the normal squabs. Moreover, kymographic records as well as direct observation revealed no characteristic difference in rapidity, magnitude, or general pattern or in any other aspect of the reactions shown by the two groups. The nystagmus reaction shown in Record 1, though obtained from a blinded bird, is typical of the responses obtained from the normal as well as from the other blinded birds [For a description of the apparatus and technique employed in recording these responses, see Mowrer (27).]



RECORD 1

The post-rotational nystagmic response shown in this kymographic record was obtained from a five-weeks-old squab in which vision had been excluded from the time of hatching by the method described in the text. The nystagmus here shown is typical of the reactions obtained from other blinded birds as well as from birds which had been reared with normal vision The onset of retardation occurred at the point marked "x" in the signal line; the intervals in the time line represent seconds

The results of the present investigation with pigeons and of Nasiell's study with rabbits seem to offer decisive proof that, at least in these particular animals, vision is not essential for the normal development of vestibular nystagmus. These findings do not, however, necessarily prove that vestibular nystagmus is unlearned. In the case of the pigeon (and other birds showing predominantly a head nystagmus), it is possible to conceive of a way in which this reaction might be learned quite independently of vision. During the period of incubation the parent birds frequently rotate the eggs containing the developing embryos. This movement will, of necessity, stimulate the vestibular receptors as soon as these organs begin to function. On the basis of the hypothesis advanced by Holt (see above), this type of stimulation will at first elicit a variety of purely random reactions. If, however, one of these reactions happens to be of such a nature as to remove the then acting stimulus, according to Holt, in the future the probability of the occurrence of this particular response to the given stimulus will be greater than before. By such a process the probability that a given stimulus will elicit a given response is gradually increased until, in at least some cases, it amounts practically to certainty.

In the avian embryo there is one type of reaction which is specifically capable of eliminating, or at least reducing the intensity of, the vestibular stimulation produced by the passive rotation of the egg; this reaction consists of a compensatory movement of the head in the direction opposite to that in which the passive rotation occurs. That the head of the developing bird is capable of considerable independent movement before hatching is shown both by the experimental observations of Kuo (18) and by the fact that birds peck their way out of the shell. It is not at all impossible, therefore, that specific vestibular head reflexes may be established in the embryo well before the time of hatching solely on the basis of learning of the kind just suggested. After hatching, the bird begins to move about actively and the same process would presumably continue at an even more rapid pace, regardless of whether or not vision was permitted

The theory of the development of vestibular nystagmus in birds which has just been elaborated will not, however, apply in the case of mammals in which nystagmus involves only the eyes During gestation, movements of the mother undoubtedly stimulate the vestibular receptors of the mammalian embryo Compensatory movements of the head would, as in the case of birds, tend to eliminate this form of stimulation; but for some reason vestibular head reflexes do not develop as they do in birds;[5] instead, vestibulo-ocular responses appear which could not conceivably act in such a way as to abolish or even reduce the intensity of any form of vestibular stimulation. The opportunity for embryonic head movements is presumably just as good in mammals as in birds. The fact that the former develop primarily a vestibular nystagmus of the eyes while the latter develop primarily a nystagmus of the entire head tends, therefore, to suggest that if learning is involved in either case, an inherent difference in developmental potentialitities is probably also operative

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[5] The differentiation here is relative rather than absolute the newly-hatched bird has, along with the more conspicuous vestibular head reflex, also a vestibular eye reflex; and the new-born mammal likewise shows evidence of a vestibular head reflex along with the more prominent vestibulo-ocular reflex (29) Whether an organism will develop a nystagmus primarily of the entire head or of only the eyes appears to be dependent not so much upon the particular class to which it belongs as upon whether it possesses binocular or monocular vision (6*a*) For example, the rabbit, which has probably the smallest extent of binocular vision of any mammal, shows a very prominent head nystagmus On the other hand, birds of prey, having a much greater degree of binocular vision than birds that are preyed upon, show a correspondingly greater tendency toward eye nystagmus. Yet, as pointed out above, the visual experience of any given individual seems to have nothing to do with the development of that individual's nystagmic reactions. The situation is obviously complicated and calls for further experimental analysis.

Holt has suggested how, by Pavlov's law of the conditioned reflex, a "circle-reflex" (Bok) may be established so that the "passive stretching of a muscle excites it to contraction," as has been experimentally demonstrated by von Uexkull. During rotary movements of the head of a mammalian embryo, the optic bulbs, being relatively free to move in their sockets, may be thought of as "lagging behind" during the acceleration phase of such movements and "moving ahead" during the retardation phase. These purely mechanical displacements of the eyeballs, even if quite insignificant in magnitude, would presumably stimulate the proprioceptors of the eye muscles which are thus stretched This, according to Holt, should lead to the contraction of these muscles. Now at the same time that these muscles of the eyes are being stretched and excited to contraction by the inertial movement of the eyeballs, the semicircular canals are also being stimulated. Thus, by the principle of the conditioned reflex, the stage is set for the formation of the vestibulo-ocular reflexes, purely on the basis of learning.

By a process quite analogous to the one just described, it is also understandable how vestibular head reflexes might become established in the avian embryo.

There is, however, one serious difficulty with this conception of the way in which the vestibular nystagmic reflexes develop During acceleration of the head of the mammalian embryo in the clockwise direction, for example, the inertia of the eyes will tend to stretch the external rectus of the right eye and the internal rectus of the left eye. Assuming that the proprioceptive stimulation thus produced excites these muscles to contraction, the resulting movement of the eyes would be to the right If, therefore, the concurrent vestibular stimulation became conditioned to this type of eye movement, the resulting vestibulo-ocular reflex would be in the *same* direction as the head movement It is, of course, well known that exactly the reverse relationship actually exists: the vestibular stimulation produced by clockwise acceleration of the head in one direction causes the eyes to move in the *opposite* direction The writer has no suggestion to offer as to how Holt's theory of the development of reflexes in general can be made to explain the development of the vestibular nystagmic reflexes.

In the light of the results of the present investigation with pigeons and those of Nasiell's experiment with rabbits, it seems fairly certain that vision does not play a significant rôle in the development of normal vestibular nystagmus. Although it is possible to advance a hypothetical explanation of the development of head nystagmus in pigeons purely on the basis of learning (with vision excluded), the fact that it is apparently not possible to offer a similar explanation of the development of eye nystagmus in mammals tends to weaken the argument that either form of nystagmus is learned The writer is convinced that many reflexes are inherited (see Note 3) in just as strict a sense as are many structural characteristics. It is perhaps unwarranted at the present time to say that this is true of the vestibular nystagmic reflexes. Nevertheless, the evidence seems to point in this direction.

II. The Development of Optokinetic Nystagmus

Although quite similar from the point of view of the overt movements involved and the function subserved, the reactions designated as vestibular nystagmus and optokinetic nystagmus differ radically as regards their source of stimulation. Whereas the former arises from the vestibular effects of angular acceleration (or retardation) of the subject's head or entire body, the latter is elicited by movement of the subject's visual field. There is a sharp divergence of opinion —compare Bárány (2) and McGinnis (22) with Bartels (3), Galebsky (12), Kestenbaum (17), and Mygind (29)—as to whether true visual nystagmus may be elicited in human infants immediately after birth, but all investigators are agreed that this response is unmistakable and quite vigorous by the time the infant is a few weeks old Whether this postnatal improvement is more directly dependent upon the infant's visual experience (learning) or upon maturation is a problem which writers in this field appear to have given but scant attention It has naturally not seemed feasible to deprive normal human infants of vision during the early weeks of life merely to provide the experimental conditions necessary for studying this problem; and Dennis' recent review (7) of cases of congenital blindness in which vision has eventually been made possible through surgery includes no mention of any observations on optokinetic nystagmus. Animal experimentation offers, of course, excellent possibilities in this connection; but of the numerous investigators who have reared animals without vision for other purposes,[9] apparently no one has made any attempt to study the above problem.

In view of these circumstances it seemed worth while to make a study of the visual responses and particularly the optokinetic nystagmus of the ten squabs which were reared without vision for the experiment described in the preceding section of this paper. At six weeks of age, after they had been tested for vestibular nystagmus in the manner already described, the birds were given the opportunity for normal vision by removing the stitches which had previously held the eyelids together. Their eyes were almost always found to be clean, free from irritation, and perfectly developed. For five or ten minutes after the eyelid sutures were removed, the birds often tended to blink excessively or to keep their eyelids partly or entirely closed. Whether this merely represented faulty muscular control or was due to temporary photophobia or dark-adaptation is not certain. But whatever may have been the cause of this behavior, it

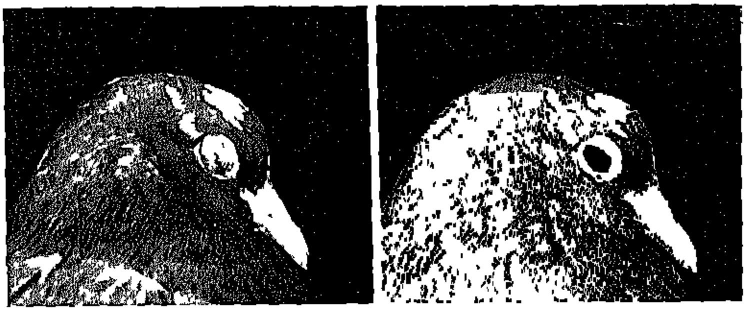

FIGURE 1*a* FIGURE 1*b*

Figure 1*a* shows a six-weeks-old squab whose eyelids had been sutured together from the time of hatching. Figure 1*b* shows the same bird about twelve minutes after the sutures had been removed. This method of excluding vision does not interfere with the normal development of the eyes and does not result in any impairment of control over the lids subsequent to the removal of the sutures.

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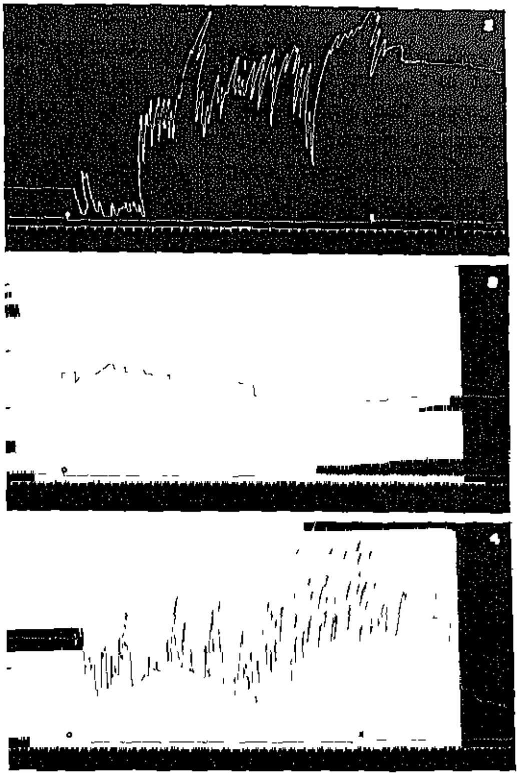
[9] For a review of this literature, see Goodman (13).

usually disappeared within a quarter of an hour or less and did not subsequently reappear. The photograph shown in Figure 1*b* was taken about twelve minutes after the photograph shown in Figure 1*a* and shows no trace of the "squinting" tendency just referred to

For several hours after their eyes were opened, the birds appeared to be completely "blind" in all ordinary situations They continued to walk much as they had previously, holding the head extended stiffly forward and showing none of the rhythmical head movements which are characteristic of pigeons which have had normal visual experience (9). They showed no capacity for avoiding obstacles placed in their path and were entirely unaffected, so far as could be determined by their behavior, by rapid movements of the experimenter's hands or by the waving of a handkerchief a short distance from their eyes The birds did, however, show a prompt and vigorous pupillary reaction when a 30-watt electric light was turned on a few inches from either eye This latter finding differs from the observation of Goodman (13), who reported that a rabbit reared in complete darkness showed a long pupillary latency (five seconds) when first subjected to visual stimulation This difference in the promptness of the pupillary reaction *may* be explainable by the fact that the intensity of the light which diffused through the sutured eyelids of the pigeons naturally fluctuated considerably and may thus have provided the pupillary reaction with sufficient "practice" to bring it to a high degree of functional perfection prior to the opening of the lids Or, again, there may be a characteristic difference in the way in which the pupillary reflex develops in these two different species The problem is an interesting one and should be studied further

If, at six weeks of age, a squab which has had normal visual experience is placed in a suitable holder and a large, well-illuminated cylinder with a variegated interior is rotated around the bird, the bird shows a vigorous horizontal head nystagmus The kymographic record which is labeled "2" in the accompanying reproduction is typical of the reaction which is produced by revolving the cylinder in the clockwise direction at the speed of one revolution in about five seconds. In this record the intervals in the time line represent seconds and the distance between "*o*" and "*x*" indicates the period



RECORDS 2, 3, AND 4

The optokinetic nystagmus shown in Record 2 is typical of that obtained from six-weeks-old squabs which have been reared with normal vision. From "o" to "x" along the signal line represents the interval during which the visual environment surrounding the bird was in rotation. In Record 3 may be seen the response obtained under the same test conditions from a bird which had been reared to the age of six weeks with eyelids sutured together and whose lids had been opened only about a quarter of an hour before the record was taken. Record 4 shows the nystagmic response which was obtained from the same bird three days after the eyelids were opened.

during which the cylinder was in motion. The bird's actual responses were three times the magnitude shown in this record.

When the birds whose eyelids had been sewed together were tested

15 or 20 minutes after their eyelids had been opened, under the conditions just described, the response obtained was usually somewhat similar to the one shown in the record labeled "3." In this particular record the bird shows a consistent though very feeble tendency toward a normal nystagmus But in several of the other birds, not only was the magnitude of the nystagmus extremely small, but the pattern of the response was also quite abnormal For example, instead of showing the typical alternation of slow pursuit head movements in the direction in which the visual field is moving and quick saccadic movements in the opposite direction, the birds frequently made simply a succession of irregular saccadic movements in various directions Although infrequent, it also occasionally happened that a bird would show a slow drift of the head in the direction opposite to that of the normal pursuit type of movement However, when retested for optokinetic nystagmus three days after their eyelids had been opened, the birds uniformly showed a response which was completely indistinguishable, both as regards pattern and magnitude, from the response of birds which have been reared with normal vision[7] Record 4 is typical of the responses obtained from the previously blinded birds on the retest.

In view of the almost complete absence of optokinetic nystagmus immediately after the eyelids of the previously blinded birds were opened and the rapidity with which this response subsequently developed, it seems justifiable to conclude that optokinetic nystagmus, unlike vestibular nystagmus, is probably entirely learned[8] There are two ways in which this might come about It is fair to assume that a moving retinal image constitutes a relatively intense form of stimulation which elicits in the young organism a series of at first random responses. If, however, among these responses there chances to occur a movement of the head and eyes together (or of only the eyes) in the same direction as the movement of the visual field, the image on the retina will become more or less stationary and the intensity of the stimulus will be greatly reduced. Therefore, through the operation of the principle which Holt (15) has clearly formulated (see preceding section), this type of response will eventually become specifically tied up with the stimulus which it tends to remove or weaken

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[7] Three days subsequent to the opening of the eyelids was selected more or less arbitrarily as the time for the retest Since there were no intervening tests, it is impossible to state the exact time required for the acquisition of a normal optokinetic nystagmus, all that can be said is that it was something less than three days

[8] The fact that most of the birds showed an incipient tendency toward a normal optokinetic nystagmus when first tested may be interpreted as indicating that the first stages of the learning process which was to bring this type of response to its mature form and magnitude were already in operation

The other way in which optokinetic nystagmus may be learned is this As was pointed out in the first section of this paper, the development of vestibular nystagmus is probably exclusively dependent upon maturational factors Under ordinary conditions rotary movements of the head, which cause the retinal image to move, also produce vestibular stimulation which, by virtue of pre-established neural pathways, elicits a vestibular nystagmus. By a simple process of conditioning, it is understandable how movement of the retinal image alone might eventually come to elicit the type of response (nystagmus) which occurred originally only to vestibular stimulation

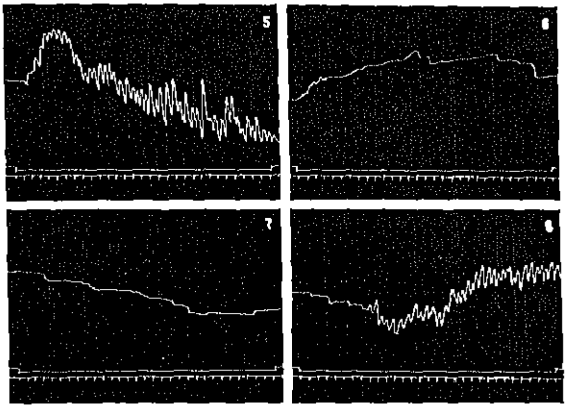
On the basis of the available evidence it is impossible to say which, if either, of the two foregoing explanations of the way in which optokinetic nystagmus develops is correct. It is, however, fairly certain that this type of response is acquired through some sort of learning process rather than through maturation, as appears to be the case in the development of vestibular nystagmus Although it had not previously been shown that such a difference exists in the ways in which these two types of nystagmus develop, this finding might have been predicted on purely neurological grounds. In mammals the retino-ocular reflexes involved in optokinetic nystagmus are known to be mediated by neural tracts which pass through the cerebral hemispheres (28), whereas the vestibulo-ocular reflexes involved in vestibular nystagmus are mediated by strictly subcortical mechanisms (25) In the light of these anatomical relationships and the relatively rigid, genetically predetermined organization of the brainstem as contrasted to the great lability of the cerebral hemispheres, it is quite understandable why optokinetic and vestibular nystagmus should develop in characteristically different ways.

There has long been reason for assuming that in birds the retinomotor reflexes involved in optokinetic nystagmus, unlike the analogous reflexes in mammals, are mediated by subcortical rather than by cortical pathways (6*a*), and Visser and Rademaker (35) have recently confirmed this view by showing that the cerebral hemispheres of the pigeon can be completely extirpated without noticeably disturbing this type of response However, even in birds the retino-motor pathways pass through the brain at a much higher level than do the vestibulo-motor pathways. The former pathways are known, for example, to pass through the corpora quadrigemina, in the roof of the mid-brain, and, since these bodies have a very considerable cortex of their own in birds, there is thus provided an opportunity for the "learning" of optokinetic nystagmus, whereas there is apparently no such provision for a similar process along the vestibulo-motor pathways. It is therefore possible to show, in both birds and mammals, neurological reasons why the experimental results reported above should have been obtained.

III. THE TRANSFER OF TRAINING FROM ONE EYE TO THE OTHER IN THE DEVELOPMENT OF OPTOKINETIC NYSTAGMUS

Experiments by Wallin (36), Lashley (19), and Franz and Layman (11) have shown that visual habits established by stimulation of only one eye may be elicited, with virtually the same degree of promptness and completeness, by subsequent stimulation of the unpracticed eye. So far as the writer is aware, however, no attempt has previously been made to determine the extent to which specific visual responses which are established in individuals possessing only monocular vision from birth "transfer," if vision is later made possible in the previously unseeing eye and excluded in the previously seeing eye Conditions appropriate for obtaining information relevant to this problem were created by suturing the right eyelids of four squabs by the procedure described in the first section of this paper By the time these birds were four or five weeks old, they were capable of efficient flight and normal feeding and defense reactions; in short, their behavior was quite indistinguishable from that of normal squabs, except for the fact that the absence of vision on the right side of their heads caused their peering head movements (which serve very much the same function as voluntary saccadic eye movements in man and most other mammals) often to be of extreme magnitude, due to the necessity of turning the head through approximately 180° in order to have vision on the right side of the body.

Since the birds described in Section I developed a perfectly normal vestibular nystagmus despite the exclusion of vision from both eyes, it did not seem likely that the exclusion of vision from only one eye would affect the development of this response. Consequently no attempt was made to test this reaction in the four birds just referred to. However, a careful study was made of their responsiveness to the revolving cylinder described in Section II. During these studies it was found that when the cylinder was rotated in the clockwise direction, that is to say, toward the beak on the side of the seeing (left) eye, all four birds showed a fairly vigorous optokinetic nystagmus, of which Record 5 is representative. That this response was not, however, as vigorous as that obtained from birds possessing vision in both eyes (Record 2) is perhaps understandable. But what came as a complete surprise was the finding that when the cylinder was rotated in the counterclockwise direction, that is to say,



RECORDS 5, 6, 7, AND 8

Record 5 was obtained by rotating a visual environment in the clockwise direction about a five-weeks-old squab in which vision in the right eye had been excluded from the time of hatching by means of eyelid suture. Record 6 was obtained by rotating the environment in the counterclockwise direction. A few minutes after Records 5 and 6 were secured, the bird's left eyelids were sutured together and the eyelids of the right eye opened. Record 7 was then obtained by rotating the environment clockwise, and Record 8 by rotating it counterclockwise.

away from the beak on the side of the seeing eye, the response was very slight and highly irregular, as is shown in Record 6.

After the above observations had been completed for each of the four birds, they were put under light ether anaesthetic and the stitches removed from the right eyelids and the lids of the left eye sutured. Approximately a quarter of an hour later, after they had recovered from the anaesthetic, the birds were again tested for optokinetic nystagmus. In a manner perfectly consistent with their earlier performance, they now showed little or no response to movement of the cylinder in the clockwise direction, i.e., away from the beak on the side of the seeing (right) eye, but gave a lively response to movement of the cylinder in the counterclockwise direction, i.e., toward the beak on the side of the seeing eye, as is shown respectively in Records 7 and 8.

When these birds which had previously had vision in only the left eye and which now were given vision in only the right eye were tested under ordinary circumstances, their behavior was in striking contrast to that observed when the sutures were removed from the eyelids of the birds previously possessing vision in neither eye (Section II). Although their responses were not quite so well coördinated as they had been with the left eye open, immediately after the right eye was opened (and the left eye closed) these birds avoided obstacles placed in their pathway, flew and alighted without mishap, pecked up scattered grains, showed the usual fright reactions when approached by the experimenter, and, in general, behaved very much as they had before vision was shifted from the left eye to the right eye. That the area of efficient vision was not quite so great in the right eye as it had been in the left was evidenced by the fact that it seemed necessary for the birds to look more directly at a given object in order to see it than formerly. This deficiency in peripheral vision rapidly disappeared, however, and was not detectable after 24 to 48 hours.

Visual responses acquired through the functioning of only one eye are thus seen to "transfer" almost completely to the other, previously unseeing, eye. This finding accords with the results of the investigations cited at the beginning of this section, which indicate that the same relation holds in cases where a given habit is acquired with the vision of the unpracticed eye eliminated only during the period of practice of the other eye. In passing it may be mentioned that the tendency on the part of the young pigeons just described to react more vigorously to movement of the visual environment in the direction toward the beak on the seeing side than in the opposite direction has also been observed by the writer in adult birds which had had normal visual experience. This phenomenon, however, has been discussed in another paper (28) and will not be further considered here

IV SUMMARY

Pigeons which have been reared to five weeks of age with vision excluded by means of eyelid suture show a vestibular nystagmus in response to bodily rotation which is both quantitatively and qualitatively indistinguishable from the vestibular nystagmus elicited by similar stimulation in birds of the same age which have been reared with normal vision. The supposition that the development of this type of response is dependent upon a learning process in which vision plays an essential rôle is thus controverted. Various other possibilities of explaining the origin and development of vestibular nystagmus on the basis of learning have been considered but have been found to be inconsistent with the experimental facts. In the absence of any evidence to the contrary, it appears necessary to conclude, tentatively at least, that the development of this type of response is dependent primarily, perhaps exclusively, upon the inherited pattern of organization of the nervous system

Pigeons which have been reared to six weeks of age with vision excluded by means of eyelid suture show, immediately after the removal of the stitches, (*a*) normal pupillary reactions to changes in light intensity, (*b*) no fear or avoidance reactions, and (*c*) a very feeble, irregular optokinetic nystagmus. Within three days after the removal of the stitches from the eyelids, these birds develop a normal optokinetic nystagmus and normal fear and avoidance reactions. The rapid development of these reactions after vision is made possible apparently comes about as a result of learning At least this can be said, that, if maturational factors are also involved, they alone are not sufficient to bring these responses to functional maturity

It is pointed out that the fundamental difference which is thus evident in the way in which vestibular and optokinetic nystagmus develop might have been predicted on purely neurological grounds.

Visual responses acquired by pigeons which have been reared to six weeks of age with vision in only the left eye appear to "transfer" almost completely when vision is shifted to the right eye. This finding agrees with the results of earlier experiments on intra-ocular transfer of specific visual habits acquired with vision excluded from the non-practiced eye only during the period of training.

When a visual environment is rotated around a pigeon in which vision is permitted in only one eye, the bird shows a much more vigorous optokinetic nystagmus when the environment moves toward the beak on the side of the seeing eye than when it moves in the opposite direction. The probable explanation of this phenomenon is discussed elsewhere

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THE INFLUENCE OF A "VOLUNTARY" REACTION UPON THE DEVELOPMENT AND THE EXTINCTION OF THE CONDITIONED EYELID REACTION*

From the Psychological Laboratory of Oberlin College

JOSEPH MILLER AND L. E. COLE

INTRODUCTION

This study was originally undertaken in an endeavor to discover a method of establishing relatively stable conditioned responses, and to discover the factors which produced the stability. The lid reflex, originally conditioned by Cason in 1922, and later used by a number of investigators of conditioned responses, was selected. An earlier study in the Oberlin laboratory[1] had shown that a complex stimulating situation, while not increasing the stability of the response, leads to greater frequency of appearance than does a single isolated conditioned stimulus. It was desirable in the present study to obtain a high frequency in order to base all results regarding stability upon a well-established response which would not require a large number of sittings for its establishment. Therefore, a sequence of stimuli of three modalities, sound, light, and tug, regularly preceded the unconditioned stimulus during the course of conditioning

REVIEW OF THE LITERATURE

In 1928 Schlosberg (13) reported a study of the conditioned knee-jerk in which the movement was "facilitated" by a voluntary reaction to the conditioned stimulus. As one of his conditioned stimuli Schlosberg employed the blow administered by a weighted stylus which fell upon the subject's hand 0 2 seconds before the blow

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[1] An unpublished report on the conditioned eyelid reflex on file in the Oberlin Psychological Laboratory In this study the method employed by Bernstein (1) was paralleled except that two continuous and changing stimuli were used in place of the momentary click which Bernstein used as the conditioned stimulus.

on the patellar tendon His subjects were instructed to respond by lifting the stylus immediately after it struck. The results of this procedure, when compared with those of subjects who did not lift the stylus ("non-facilitated" group), showed that the effect of the hand movement was to produce consistently higher frequencies. The same results were obtained from other forms of facilitation such as clenching the fists, or saying "Ah" Schlosberg reported that no stable conditioned responses were formed in any of the procedures

Wendt (19) reported a study of the conditioned knee-jerk in which both knees were stimulated, one very shortly before the other With repeated stimulations the first blow came to be the conditioned stimulus for the kick of the other leg Here, as in Schlosberg's experiment, there was a concomitant muscular activity, namely, the reflex kick of the leg which received the first blow. Such a movement, although not voluntary in this case, should also prove to have a facilitating effect.[2] Wendt found that a conditioned response obtained under these conditions was unusually stable; one subject responded at least 400 times without reinforcement, and another retained the response over an interval of four days[3]

Hudgins (5) succeeded in conditioning the reactions of the human iris to various stimuli, among them hand contractions against a dynamometer, and vocal and sub-vocal verbal reactions He succeeded in reducing a complex of conditioned stimuli to the simple case of sub-vocal self-stimulation, the conditioned response remaining intact throughout. He found, in fact, that at this last stage of the conditioning procedure the response was much more resistant to extinction than it had been at any of the previous stages, and that one subject acquired the ability to report correctly and control completely the direction of change in the diameter of the pupil Furthermore, this control persisted for some time[4]

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[2] This investigator did study the facilitating and inhibiting effect of the double stimulation with reference to the amplitude of the reflexes, but there was no comparison of the conditioning with the simpler situation involving only the one leg Cf. Schlosberg

[3] This was the case only with the "unilateral secondary responses" Wendt's long latency response, the "true" conditioned response, was rapidly extinguished. Wendt considers the persistent response "different from the conditioned responses usually described," probably "an exaggeration of a reflex discharge normally present in the knee-jerk so that it does not show negative adaptation to a marked degree" (19, p 68-69)

[4] Steckle and Renshaw (17) have failed to corroborate Hudgins' findings They report that they could not establish a clear-cut iridic conditioned re-

One of Hudgins' control experiments is germane to this report. He found that, when the hand contractions were omitted from the regular procedure in the transition from the first to the second step of his experiment, there was no conditioned response after 410 trials, after the hand contractions were introduced, tests showed conditioning to be present after only 80 trials.

When the results of the experiments discussed in this review are compared with those of a great number of other studies of the conditioned response, it becomes evident that muscular activity on the part of the subject, induced by instruction, may well affect the stability of the conditioned responses obtained. It was the aim of this study to vary systematically the conditions of the movement and note the results with regard to frequency and stability of the conditioned response

The movement used was a flexion of the wrist and middle finger of the left hand In one group this movement led directly to the unconditioned stimulus (shock); the completion of the hand movement closed the shocking circuit, into which the key manipulated by the subject had been wired In a second group the hand movement regularly preceded the shock, but was not directly related to it, since the shock was administered from the chronoscope after each tug. It followed the tug by an interval long enough to permit the hand movement to precede the shock. Two control groups were included; in one there was no hand movement during the entire sitting, in the other the movement was employed to administer the shock during training, but was inhibited by the subject during the test trials

APPARATUS

The apparatus employed was designed to administer the following stimuli and to record the several responses made: a light, a mechanical tug against the left wrist, and an electric shock to the right cheek A Bergstrom chronoscope was used to control the intervals between stimuli. Records were taken with a kymograph.

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sponse, much less a stable one under the subject's control Hudgins has since published a note on Steckle and Renshaw's study (*6*) Recently Hudgins concluded a series of check experiments (August 1935, unpublished) in which he again obtained conditioned pupillary responses, and carried them through all the stages of training.

The first stimulus in each trial was the flash of a 3.8-volt flashlight bulb which was inserted into the screen behind which the subject sat. The bulb was fixed at the level of the eye of the subject in sitting position It was activated by two dry-cells; the circuit was closed by the action of a "dog" switch placed directly under the releasing ratchet of the chronoscope so as to flash the light at the moment the pendulum began its swing The bulb was covered with a bit of adhesive tape to avoid glare. The closure of the light circuit was recorded on the kymogram by means of a signal magnet wired in series A knife switch made it possible to run controls in which the light was omitted.

The second stimulus in each trial was a tug on the subject's left wrist, which was fitted into a leather wrist-band, and suspended by means of a wire and wire hook from one end of an aluminum lever, 16 inches long, pivoted at the center, and supported on a ring stand. From the other end of the lever was suspended an iron plunger which served as the core of a solenoid. The suspension wires were so arranged that one-fourth of the length of the plunger was in the field of the solenoid when the subject's wrist rested on the table Thus a closure of the solenoid circuit drew the plunger into the field and administered a sharp upward tug to the wrist

Figure 1-*B* is a wiring diagram of the tug circuit The current flowing in the circuit was regulated by means of the 600-watt heater coils in series with the solenoid. With one coil in the circuit the pull was limited to 600 grams, instantaneously exerted. This pull constituted a distinctly sensible stimulus every time[5] A signal magnet was used to record the incidence of the tug. A glass enclosed tungsten wire electrode was attached to the shaft of the chronoscope pendulum so that its exposed end was carried through the mercury trough (*HG*), thus closing the circuit and activating the solenoid. As the pendulum completed its swing a key (*A*) situated at the experimenter's left hand, was opened by hand so that no tug would be administered on the back-swing.[6] The time interval between the

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[5] The tug occasionally caused winking before the conditioning began See Note 17.

[6] Such a tug was inadvertently given four times during the entire experiment, never more than once to any subject

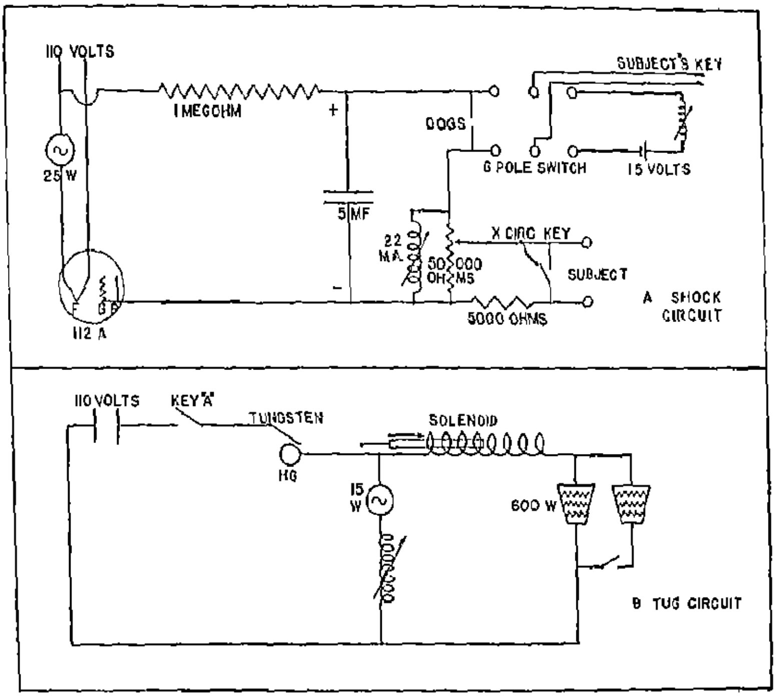

FIGURE 1

light and the tug could be adjusted by means of a set-screw in the frame of the chronoscope.

A wiring diagram of the shock circuit is shown in Figure 1-*A*. The current from a 110-volt source was limited by the 25-watt light-bulb (25*W*) and led to the filament of a rectifier tube, type 112*A*. The shocking current was the discharge of a 5-mfd. condenser, the rate of charge of which was controlled by a resistance of one megohm, which permitted the condenser to reach maximal charge in three seconds. The intensity of the shock could be varied by means of a 50,000-ohm variable resistor.

A current intensity slightly above the wink threshold was selected by preliminary tests on subjects not used in the experiment. This shock never failed to elicit the reflex wink during the experiment[7] and was reported by each subject as causing little discomfort. The duration of the shock was never more than ten sigma, which helped to reduce the disagreeable effect of electrical stimulation

Zinc electrodes, wrapped in gauze and soaked in salt solution, were used The negative electrode, elliptical in shape (1 cm. x 3 cm) was applied to the skin over the bony prominence below the right orbit The other electrode, rectangular in shape (3 cm x 8 cm), and curved to fit the arm, was applied to the surface of the right forearm.

The shock was recorded by means of a signal magnet which could be activated by a current of 20 milliamperes' intensity.

The short-circuiting switch (x-circ key, Figure 1-*A*) was used to take the subject out of the shocking circuit at times when he might inadvertently shock himself by random manipulation of his key, principally between trials in group III.

The eye-wink was recorded pneumatically by means of a system which was a modification of the one described by Bernstein (1, pp. 175-178). Changes were made to decrease the mass of the unit, to permit it to move more freely, and to eliminate all tensions which might distort the lid movement or its temporal characteristics. The movement of the lid was transmitted to the membrane of the head-end tambour through a lever made of a bamboo splint 5 cm. long and less than 1 mm. in diameter. One end of this lever was attached to the upper lid of the right eye by means of a bit of adhesive tape, the other end to the membrane of the tambour through a pivot-joint made of bamboo and celluloid, the total mass of which was negligible. The membrane was cut from animal tissue (lambskin condom), soaked first in an ether-alcohol solution to dissolve the fatty tissue, and then in glycerin to render it soft and pliable for a long period of time The membrane was loosely applied to the tambour so as to avoid all tension and permit the lid-lever to follow directly all movements of the lid The total mass of the head-piece (including the strap whose mass was evenly distributed about the head) was 73 grams No subject reported any discomfort from either the strap or the lid attachment.

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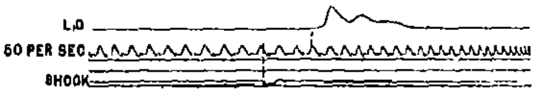
[7] Two subjects showed a tendency toward inhibition of the reflex wink to shock during the training period. They were Boy, in Group III, and Ran, in Group II.

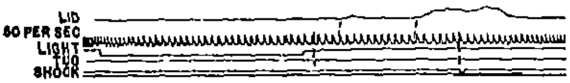
Such a recording system has the great advantage of being light, readily adjustable in all dimensions, and free of friction, tension, and the momentum of rapidly moving parts Perhaps its greatest advantage for recording the movements of the lid is that it requires no head fixation, permitting the subject to change the head posture at any time without interfering with the recording, and greatly reducing fatigue and consequent difficulties.

The movements of the tambour diaphragm were transferred to the kymogram through 250 cm. of glass and rubber tubing and a pneumodeik [8]

Illustrations of typical records obtained are presented in Figure 2.



A REFLEX WINK TO SHOCK



B CONDITIONED WINK, NO HAND MOVEMENT.

FIGURE 2

LENGTH OF ORIGINAL TRACING, 12 CMS

SUBJECTS

Forty-two persons served as subjects, each for only one experimental sitting, which lasted from 40 to 90 minutes All subjects were students in Oberlin College, three were acquainted with the problem, while 39 were naive in this regard They were divided into the four groups which follow.

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[8] Glass tubing of 10-mm bore was used wherever possible Large bore rubber tubing was used for joints and portions of the line where flexibility was needed Experience in the Oberlin Psychological Laboratory has shown that the impulse transmitted through the line by a high speed movement is a condensation-rarefaction wave with many characteristics of a low-frequency sound wave. Preliminary tests made while the apparatus was being assembled showed that the large bore glass tubing gave *ca* 30 per cent greater transmission efficiency than rubber tubing of smaller bore The pneumodeik used in this study is essentially the same as the original model described by Hudgins and Stetson (7)

> *Group I* Ten undergraduate students, three male and seven female. All but one (Fol) were naive as to the concept of conditioning and the purpose of the experiment
>
> *Group II.* Fifteen students, eight female and seven male All but one (Sper) were naive with regard to the nature of the experiment
>
> *Group III.* Ten students, four female and six male. Two were graduate students, the rest undergraduates, all were naive regarding the purpose of the experiment
>
> *Group IV.* This group was limited to seven students whose performances were very consistent and showed clearly the differences sought Six were male, one female, all were students in the 1935 summer session. All were naive regarding the nature of the experiment.

PROCEDURES

Group I. In this group there was no hand movement The customary pairing procedure was employed except that a complex of stimuli, rather than a single isolated stimulus, regularly preceded the shock, which was administered from the chronoscope. This complex consisted of the starting sound of the kymograph motor (which must be counted a conditioned stimulus, although it was not recorded or considered in the treatment of the data), the flash of the light, and the tug This group serves as a control, and should yield a relatively low frequency and stability if the hand movement proves to be a significant conditioning factor The subject was instructed to find a comfortable posture and to rest his hand and left forearm upon the table, with one finger resting lightly on the key The left wrist was fitted into the wristband and the function of the band explained He was instructed to receive the tug passively, fixate upon the light, and to report any fatigue or discomfort caused by the apparatus Regular rest periods were provided. The sitting was then divided as follows.

> 1 Four to eight trials with the light alone, to test for reflex winks to the light, the drum motor-driven.

2. Three to six trials of the light followed by the tug to test for winking to the tug The tug followed the light by 0.75 sec.[9]
3. Three to six trials of the shock alone to test the adequacy of the stimulus The light was disconnected and the drum spun by hand, eliminating all visual and auditory cues
4. Fifty trials of the light–tug–shock sequence The interval between tug and shock was adjusted at 0.38 sec
5. Light and tug, as many trials as were needed to extinguish the conditioned response

Group II. In this group the subject responded to the tug by closing the key circuit. The shock was administered from the chronoscope at an interval of 0 375 sec after the tug This group would give evidence of any difference between the mechanically administered and the self-administered shock A lower frequency or stability than in the self-shocking group cannot be the result of the difference in time intervals between the conditioned and unconditioned stimuli since the experimental evidence preponderantly favors an interval of the order of 0.4 sec over one varying about an average of 0 2 sec (the average interval for the group in which the shock was self-administered)

The instructions to this group were the same as to group I except in regard to the tug. The subjects were told to press the key as soon as they felt the tug Prior to the training trials, controls were run just as in group I, with the addition of three to six trials with the hand response to the tug, to check against any winking elicited by the combination of tug and hand response. The temporal sequence of stimuli was the same as in group I [10] Experimental extinction of the conditioned response followed the training trials.

Group III The same instructions were given as in group II, and the same preliminary controls were run The light preceded the tug by 0 77 sec The shock was self-administered by closure of the subject's key, and the interval from tug to shock therefore varied as the subject's reaction time to the tug. In no case was the average reaction time of any subject in group III as long as the interval from tug to shock in group II

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[9] The interval varied from subject to subject, from 740 to 780 sigma Within any one sitting the variation was never more than 10 sigma.

[10] The tug followed the light by 775 sigma, varying for the different subjects from 760 to 800 sigma For one subject, Ruck, the tug electrode was accidentally moved by the experimenter after the 40th trial, changing the interval from 780 to 710 sigma, and with it the tug-shock interval from 370 to 440 sigma There was no perceptible effect

The subjects in group III were not told that their hand movements would produce electrical stimulation Many inquired whether such was the case, but none were informed until the conclusion of the sitting, since all had been told previously that no inquiries of any kind would be answered until the sitting was concluded

Group IV. The training procedure and experimental conditions followed with this group were in no way different from group III. At the end of the training period, however, each subject was told to inhibit the hand response to the tug by permitting the hand to rest passively on the key This group was run to determine whether the continued hand response was vital to the stability of the conditioned response, or, in other words, to determine whether the lid reaction was conditioned to the tug (conditioned stimulus) or to the hand movement.

Kymograph records were taken of all preliminary tests, and of each trial in the training and testing periods for all subjects.

RESULTS

The Form of the Conditioned and Unconditioned Reactions. Figure 2-*A* is a reproduction of a tracing taken from a reflex wink to the shock prior to pairing with the conditioned stimuli. The movement begins 45 sigma after the shock,[11] reaches its maximal rate in about 10 sigma, and continues at a constant velocity until the closure is complete. The constant velocity is indicated by the fact that the curve is a straight line from the point at which maximum velocity is attained to the end of the closing phase of the wink.[12] This characteristic is typical of *all* unconditioned reflex winks, and forms the principal basis for differentiating between the conditioned and the unconditioned reactions with respect to form

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[11] A correcton of 10 sigma has been made in reading the lid line, since this is the lag between the pneumatic line and the timing magnet

[12] When a pivoted stylus is used to record movements of large amplitude, correction for arc distortion is necessary, especially at large angles of displacement. In the case of the eyelid response, however, the angle through which the stylus turns is very small and the distortion is below the limit of error of the recording system

The momentum movement, the outstanding characteristic of which is the straight line tracing over the greater part of the excursion of the member, has been differentiated from the tense, or controlled, movement on the basis of the muscular action involved. It has been found that in the momentum movement the driving muscle (in the eye-wink reflex, the orbicularis) contracts to start the member on its path, and thereafter remains *relaxed* while the member flies free to complete its excursion. For this reason it has been called the "ballistic" movement. Since both members of the antagonistic pair (or group) of muscles are relaxed, the momentum attained by the moving member carries it through its excursion at a constant velocity until the movement is stopped, either mechanically (by the structural characteristics of the joint) or by contraction of one or more of the antagonists

In the case of the eye-wink, for example, the lid is started from the poised open position by a sudden contraction of the orbicularis which ceases while the lid is in motion, so that the remainder of the descent of the member is carried out under conditions of muscular relaxation. The movement is stopped either by contact with the rim of the lower lid in case of complete closure, or by contraction of the levator which takes up the momentum of the downward movement and initiates an opening movement.

The tense movement, on the other hand, is characterized by contraction of both antagonists throughout the excursion. In the conditioned wink, for example, both the orbicularis and the levator are contracted during the entire movement, with the orbicularis component exerting the predominant force during the closure phase, with the contraction balanced while the lid is held in the closed position, and with the levator component predominant during the opening phase of the wink The tracing of such a movement will therefore show a gradual and often varying slope during the closing and opening phases and an irregular line while the lid is held in a fixed position. The irregularities in the line are due to the muscular tremors which may be demonstrated in any tracing of a member held in position by muscular opposition, since the balance of forces between the muscles is never perfect. The winks in Figure 2 illustrate this difference between the reflex and the conditioned reaction very clearly. It is to be noted especially that the initial phase of the conditioned response never gives the straight line tracing which is seen in the reflex.[13]

The differences in form between the conditioned and unconditioned reactions as seen in Figure 2 confirm the general findings in this respect The curves published by Schlosberg (13), Wendt (19), Bernstein (1), and Hilgard (2) are strikingly similar.[14]

The latency differences between the reflex wink and the conditioned response have been reported in many studies. A random sampling (400 winks) of the records of thirty of the subjects tested in this study gives a reflex latency of 49 sigma, A D 44 sigma, for the wink to the shock here employed. This agrees with the latent times reported elsewhere (1, 2, 4). The conditioned response anticipated the shock in every case, and persisted until after the shock had been administered. This was characteristic of every well-established conditioned response recorded in this experiment. In some of the subjects it began by appearing earlier and earlier, decreasing the latent time of the wink, until it finally preceded the shock. Once it preceded the shock, it did so invariably.[15] The latent time of the conditioned response has always been found to be much longer than that of the reflex Several investigators have reported it to be of the order of the voluntary response (1, 2, 19). Measurements of this value, taken from the subjects in group I, show it to be 304 sigma, A.D. 55 sigma (279 cases).[16] This latency agrees with the general findings

Development of the Conditioned Response. Eleven of the 42 subjects in the four groups responded with the conditioned wink on the second training trial. All but two of these responses were of full amplitude, and, therefore, in these cases the conditioning might be considered complete upon the second presentation of the training stimuli. Such results are in agreement with those reported for conditioning an "investigatory reflex" in rats by Skinner (16)

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[13] The discussion of the muscle action in the wink is based in part on unpublished action current records secured by L. E Cole and J M Snodgrass by methods developed in the Oberlin Psychological Laboratory. The reader interested in a detailed discussion of the two types of movement, tense and ballistic, will find it in the study by Stetson and Bouman (18)

[14] It is interesting to note that the conditioned winks obtained from dogs by Hilgard and Marquis (4) show the same straight line closure as do the unconditioned reflexes

[15] For a discussion of this characteristic of the conditioned reaction see Hull (8).

[16] The other groups were not used for these calculations because the hand movement influences the latent time of the lid response, as will be seen from the discussion of the two responses (hand and lid)

Nine subjects yielded their first conditioned response on the third trial, two subjects on the fourth trial, and seven on the fifth trial By the end of the first five training trials, then, the conditioned response had appeared in 29 of the 42 subjects

The comparative rates of development for the four groups are shown in Figure 3. It is to be noted that a period of slow initial

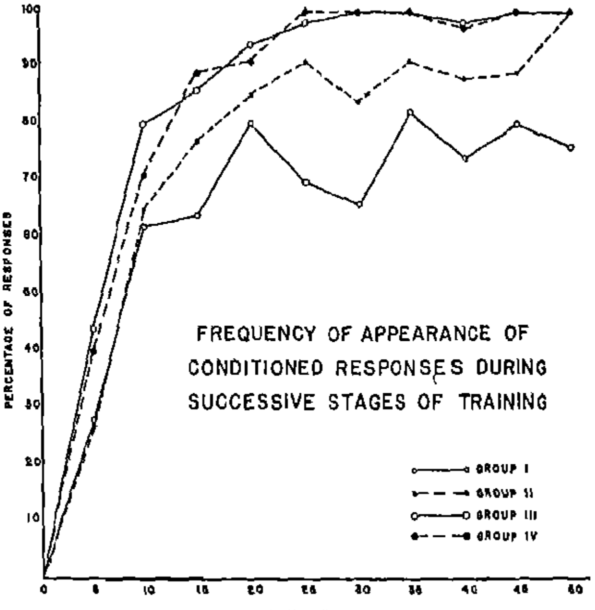

FIGURE 3

rise with increasing rate of acceleration is not present in these curves Such curves, the S-shaped type, have been published by Kleitman and Crisler (9) for conditioned salivary reactions in dogs, by Wendt (19, p 43) for conditioned knee-jerks in human subjects, by Hilgard (3) for the lid reaction in human subjects, and by Hilgard and Marquis (4) for the lid reaction in dogs. The latter investigators consider this type of curve to be representative of all conditioning, regardless of the responses involved or the species of the subjects employed (p 53).

There are several factors which may account for this difference between the curves in Figure 3 and those published by the investigators mentioned above. The explanation lies in the fact that in none of the previous studies has such complete conditioning been accomplished in *one sitting*. The factors which operate to produce 80 per cent conditioning in the least conditioned of the four groups by the twentieth trial, and 100 per cent conditioning in two other groups by the twenty-fifth trial make the situation here employed more like the learning situation for which the characteristic curve is similar to those in Figure 3 It is true that the routine conditioning procedure, based upon the formula of stimulus substitution advanced by Pavlov, and following the traditional Pavlovian method, is represented by an *S*-curve of acquisition. This means merely that such simple pairing procedure somehow falls short of the situation found in simple motor learning This fact has long been held as one of the great weaknesses of the conditioned-response theory of learning, since the problem set in laboratory conditioning is simple enough to be solved without the protracted seance of Pavlov's followers.

In group I, where the hand movement was not employed, it is the multiple stimulation through auditory, visual, tactual, and kinaesthetic channels, plus, in all probability, their temporal pattern (which permits the development of an expectant posture), which accounts for the steep rise of the curve. Since the difference between the various groups is rather slight for the initial portion of the curves, it is quite probable that the hand movement is not immediately effective.

There is one important difference to be noted, however, between groups III and IV, on the one hand, and I and II on the other. The fluctuations in the curve for I indicate that from the tenth trial on, the frequency values lie within the interval from 60 to 80 per cent. Group II also shows these fluctuations, but to a lesser degree; and, while it reaches the maximal frequency of 100 per cent, it is not until the end of the training. Groups III and IV, on the other hand, are quite regular and free from plateaux; they reach the theoretical limit by the 25th trial, and retain the complete conditioning until the end of the training. It is evidently not the hand movement per se which produces this phenomenon, since the hand movement is employed in group II. The factor which is responsible for this difference will be discussed below.

In group I the theoretical limit of conditioning was not reached, but the acceleration was apparently complete by the 20th trial. The failure to gain in frequency during the next 30 trials raises the question of the effect of repetition While it is possible that additional sittings would result in an increase in conditioning, raising the level to, or near, the point reached by the other three groups (19, p. 43), it is equally possible that further extension of the training would have an opposite result. Many investigators have reported that protracted training often results in progressive decrement of the conditioned response (11, p 234; 20, p. 99; 3; 15).

The precise effect of concurrent movements upon the phenomenon of progressive inhibition in extended conditioning would be a problem of considerable theoretical interest.

Frequency of the Conditioned Response No winks which appeared prior to the tug were considered for the computation of frequency, unless they endured beyond the presentation of the shock. Such cases were few in number, appearing in only 10 subjects a total of 21 times. Since these responses appeared among a total of more than 2500 recorded conditioned winks their frequency is evidently negligible. Only such responses as appeared after the tug and before the shock, or, if after the shock, within less than a minimal reflex latency, were considered in these computations, excepting the 21 winks mentioned above[17]

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[17] Unconditioned reflexes to the light and to the tug, appearing in the preliminary test periods, were shallow, of short duration, and subject to rapid negative adaptation They also reappeared in the training series and are in all probability illustrations of Hull's "type alpha conditioned reaction" (8, p 431). Whether this response is to be considered a true conditioned reaction in the sense that repeated *pairing* of the conditioned and unconditioned stimuli is necessary for their "sensitization" is an open question (1, p 184-186) All of these responses were excluded, however, from the present computations

In Figure 2-*B* the basis is apparent for differentiation between the short-latency "type alpha" response, and the longer latency response which is

Table 1 shows the frequencies and stabilities of the conditioned response for the four groups It is evident that the frequencies are higher than are ordinarily reported in the literature This is presumably due to the fact that the situation here employed is more complex, and of such a nature as to be conducive to conditioning. In the first group the situation is similar to that customarily employed in that there is no complication by the hand movements The interval from tug to shock is 385 sigma for nine of these subjects, 285 for the tenth. These values lie within the optimal range of intervals as reported by Bernstein (1), Hilgard (2), Schlosberg (13) and Wolfle (20) The amount of conditioning elicited in this group is greater than that reported in any of those studies, with the exception of Schlosberg's results when the voluntary movement is involved. This result can be accounted for in two ways: Either the stimulus pattern (motor–light–tug) causes the greater conditioning, or the tug is a stimulus of such a nature as to take on the aspect of a conditioned stimulus very readily and with great frequency While it may be that the latter is the case, the writers are inclined to believe that the stimulus pattern is the effective factor, since the mechanical blow on the hand employed by Schlosberg (13) gave low frequencies when not facilitated. Successful conditioning of such a stimulus pattern has already been reported (11, pp. 145-147). The main interest in the Russian studies of this phenomenon has been the ability of the subject to discriminate one pattern from another, e g , the same pattern in reversed order, or segments of one

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here considered as the conditioned reaction. Occasionally the two responses tended to merge, the curve failing to return to the baseline by the time the second reaction began.

A second type of wink is elicited by the light. It is of longer duration (average value determined from 264 winks, 438 sigma, A D. 109 sigma) This response was never found in the pretraining trials, it was acquired by 19 of the 35 subjects during training. This response to the light is also excluded from the computations of frequency and stability for the following reasons: (1) It is clearly not the main response developed since it appears so infrequently in comparison with the conditioned response to the tug. (2) The duration of the movement was so short that the member was invariably at rest by the onset of the tug, and, therefore, the response never closely anticipated the shock or overlapped the unconditioned reflex (3) This response, when it did appear, was not persistent, even through a single training period

TABLE 1

FREQUENCY AND STABILITY OF CONDITIONED RESPONSES IN THE FOUR GROUPS

Gp	Sub	% cdng	Sta	Gp.	Sub	% cdng.	Sta.
I	Cann	70	1	III	Guth	94	63*
	Vau	50	1		Cur	86	57*
	Cro	80	2		Ebe	88	97*
	Haw	74	5		Hei	98	20
	Shep	80	3		Ups	84	106*
	Bak	88	2		Gal	88	23
	Rus	88	3		Ben	90	55*
	Fol	69	13		Boy	78	8
	Faw	24	1		Schr	94	37
	Lyo	66	19		Zor	98	43
	Mean	69	5.0		Mean	90	50.9
	S D	18.4	5.8		S.D.	6.0	30.3
II	Ruck	90	17	IV	Dou	72	0
	Tur	78	27		Jms	76	1
	Har	82	28		Frie	96	1
	Sha	92	1		Cuy	98	1
	Sper	88	16		Wing	94	8
	Blec	82	28		Raw	96	2
	Wms	84	19		Con	90	2
	Cap	62	16				
	McK	92	92*		Mean	89	2.1
	McCl	90	27		S D	8.1	2.47
	Kai	86	17				
	Ran	14	8				
	Zel	88	14				
	Klei	80	4				
	Need	88	55*				
	Mean	80	24.6				
	S D	19.0	21.9				

Gp —Group
Sub.—Subject
% cdng.—Frequency in the training period, in per cent
Sta —Stability
*Extinction incomplete at the time the sitting was terminated

pattern with other parts omitted[18] It has been found[19] that the complication of the conditioned stimulus results in greater conditioning (10) The result obtained in group I confirms the previous finding that, when not one stimulus, but a sequence of stimuli, regularly precede the unconditioned stimulus, there is a definite increase in amount of conditioning.

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[18] Pavlov speaks briefly of the summation effect of multiple conditioned stimuli (12, p 91).

[19] See footnote, p. 405 this article

Of greater interest in this study, however, is the fact that, in the three groups in which the movement of the hand was a part of the situation, the percentages of conditioning are consistently higher than in group I. Owing to the fact that in two of the groups the individual variations are rather great, only two of the differences are statistically reliable, namely, those between groups I and III, and I and IV. Table 2 shows the critical ratio of the first difference to be 3.49, that of the second, 2.94.

TABLE 2

DIFFERENCES BETWEEN GROUPS WITH RESPECT TO

Groups	Frequency D	σ_D	D/σ_D	Stability D	σ_D	D/σ_D
I-II	11	7.54	1.46	19.6	5.95	3.35
I-III	21	6.02	3.49	45.9	9.72	4.72
I-IV	20.1	6.8	2.94	2.9	2.05	1.41
II-III	10	5.2	1.9	26.3	11.1	2.37
II-IV	9	6.12	1.47	22.5	5.73	3.93
III-IV	1	4.12	0.24	48.8	9.59	5.1

D—Difference
σ_D—Standard error of the difference

The critical ratio of the difference between I and IV is reduced by the fact that only seven subjects were employed in group IV. Since III and IV may be considered as one group with regard to training, the reliability of the difference between group I and the combined group, III and IV, may be computed. The critical ratio is 3.36. With regard to frequency, then, there is a real difference between the procedure in which the shock is self-administered at the termination of the hand movement and the procedure from which the hand movement is omitted.

There is also another difference, namely, in the reliability of the averages involved. In groups I and II the averages are least reliable, P.E.'s being 3.91 and 3.30 respectively. For the combined group III and IV the P.E. is 1.28. The respective ratios, Av./P.E.$_{av}$, are 17.6, 24.2, and 69.5.[20] This latter represents a reliability seldom found in the literature on conditioning, and indicates that the method of self-shocking offers a technique for conditioning, the resulting *frequency* and *consistency* of which are beyond the means of the routine pairing procedure for a single practice period of 50 trials.

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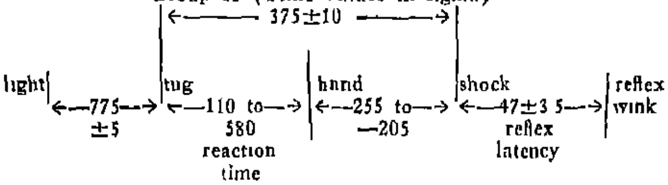
[20] For group III alone the ratio would be as great, 70.8.

It has already been stated above that the self-administered shock groups reach the theoretical maximum of conditioning early in the sitting, and maintain that maximum. It was also stated that this phenomenon did not appear in group II, and that, therefore, not the hand movement per se, but one or more particular aspects of the movement as it functions in each situation, were responsible. The difference to be sought is between the self-shocking method of group III and mechanically shocking method of group II

Such factors as knowledge of the situation, or insight into the self-shocking appear to be of no influence since all subjects in group II who were questioned at the close of the sitting stated that they had been shocking themselves by means of the key.

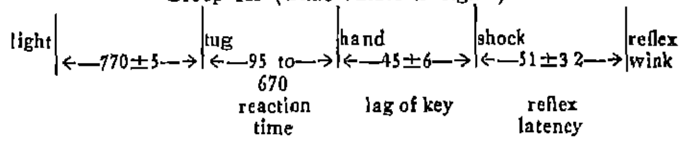
The explanation is to be sought in the difference in the temporal relations between the two groups. These relations may be shown schematically:

Group II (Time values in sigma)



It may be seen from the schema that the intervals from tug to shock and from tug to wink are fixed (the A.D. of the reflex latency is only 3.5 sigma). The intervals from tug to hand and from hand to wink vary as the reaction time of the subject to the tug from trial to trial. The range of averages for the 15 subjects is from 155 to 329 sigma; cases where the subject "jumped the gun" and actually anticipated the tug were not counted in the computation of the means. For each subject, then, the interval from the hand movement to the lid movement might vary from trial to trial with the individual reaction time to the tug. *Such variations were* *mechanically impossible in group III.* This may be seen from the schema:

Group III (Time values in sigma)



The differences between the groups are apparent The intervals which were fixed in group II are variable in group III, varying as the reaction time of the subject from trial to trial. For the ten subjects the averages range from 165 to 370 sigma. And the intervals which were variable in group II, hand to shock and hand to wink, are fixed in group III Thus, from the beginning of training, the hand and lid are forced into a temporal pattern of activity, a constant time relationship within the limits of which the conditioned response must be fitted as it appears and develops It is this time relationship which is responsible for a coordination of these two movements, of the hand and the lid, the results of which are a high, and consistently high, frequency, and, as will be seen below, an unusually high stability.

The lag of the key and the latency of the reflex separate the two movements by 80 to 110 sigma (av , 96), with the hand preceding the lid But, since it is an invariable tendency of the conditioned response to anticipate the unconditioned stimulus where conditions permit, the disparity between the hand and lid is reduced. It might be expected that the conditioned reaction would continue to move further forward, but it is presumably cued by the tug, and with the long latent time of such responses, of the order of a voluntary response, it comes to rest in the neighborhood of the hand movement Therefore, the result of training in this self-shocking situation (and very few repetitions are really necessary; see Figure 3) where three factors, viz., initially close temporal relation, the anticipatory tendency of the conditioned reaction, and the latency of the conditioned reaction, force the two movements into a rough synchrony—the result of training in this situation is the integration of the two movements into a single segment of the posture which is induced in the subject by the instructions (i.e , relative to the hand movement).

Such an integration provides the basis for more thorough conditioning than is customarily obtained. (Discussed again below, in connection with stability, and with reference to Figure 5).

The Stability of the Conditioned Response. Table 1 shows also the stability of the conditioned response in each group. Stability is here defined in terms of the number of conditioned responses appearing in successive unreinforced trials until extinction is complete. Three successive failures to respond was the criterion of extinction. This provides what has come to be known as "extinction beyond zero" (11, p. 57).

The testing period began without delay at the conclusion of training, and continued until extinction was complete, except for the seven subjects designated in Table 1. With these subjects it is obvious that the assigned stability values are incorrect, and tend to lower the averages in these two groups.

The mean stability in group I is seen to be near the usual value obtained in such a situation (1, 5, 19, 9). This average is of very little significance in view of the large individual variations. In eight of the ten subjects, however, the tendency toward very rapid extinction is quite clear. The median value of 2.5 conditioned reactions probably represents more closely the true central tendency for this situation.

For group II the reliability of the mean value of 24.6 is also impaired by the individual differences, the range of which extends from 1 to 92. Table 2 shows, however, that the difference between groups I and II is statistically reliable, the critical ratio being 3.35.

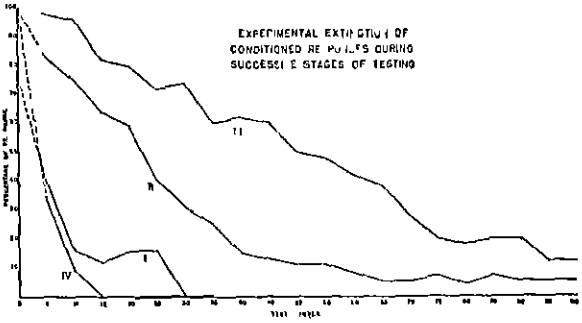


FIGURE 4

Figure 4 also indicates the difference in rate of extinction between these two groups On the basis of the difference shown in Tables 1 and 2, and the comparative rates of extinction as seen in Figure 4, it may be concluded that the situation employing the hand movement yields a conditioned response more resistant to extinction than does the simple pairing technique.

The greatest individual stability and the greatest group stability are to be found in group III, the former being 106 and the latter 50 9 conditioned responses. Figure 4 shows that the extinction in group III is a smooth and continuous process, lacking the period of negative acceleration which is present in the other groups to a greater or lesser degree A line of "best fit," applied to the extinction curve for group III, would be a straight line with a negative slope of 0 5.

It is seen in Table 1 that the standard deviation for group III is also rather large. Despite this fact the difference from group I is apparent. The critical ratio of this difference is 4.72. The difference between II and III falls short of statistical reliability, the critical ratio being 2.37 It must be remembered, however, that this ratio is lowered by the failure to reach extinction in five of the subjects in group III, as against two subjects in group II It may also be noted that Boy was the only one to develop an unstable response in group III This subject was also one of two who, in the entire group of 42 subjects, developed an active inhibition to the shock during the training In Boy the unconditioned reflex to shock decreased rapidly in amplitude during the first ten trials and soon disappeared It reappeared as the training proceeded. Since the computations are based upon all subjects rather than upon those who developed only positive conditioned responses (no such criterion having been chosen at the start of the experiment), Boy's records could not very well be rejected, despite the fact that his behavior was atypical

Had it been possible to continue the sittings which were terminated before extinction was complete, the difference between the averages for the two groups would have been greater, especially since Ups and Ebe showed little sign of approaching extinction at the conclusion of their sessions. The other three subjects, as well as the two in group II, would have yielded greater stabilities than was actually the case. The question of the existence of a genuine and reliable difference in stability between groups II and III should be cleared up by collecting more data

It has already been stated that III and IV behave as one group in regard to the rate of acquisition and the amount of conditioning This may be seen in Figure 3 and Table 1 When the hand movement, which produces the shock in both groups during training and continues as part of the testing situation in III, is omitted from the test trials in IV, a startling difference results The mean stability of group IV is 2.1, the extinction rate is steeper than in any other group. The conditioned response, although as fully developed in training as that in group III, is almost immediately extinguished.

This group was included in the experiment to determine whether the hand movement was vital to the continuance of the conditioned response when once established. It was considered possible that the thoroughly established conditioned reaction would resist extinction even if the hand movement were omitted at the conclusion of training. The inclusion of this group is therefore crucial for the question of the integration of the two movements, hand and lid If such an integration does arise in the practice period, elimination of the one movement during the tests should also eliminate the other. The results obtained show very clearly that the elimination of the hand movement in the test trials radically alters the stability of the conditioned reaction It is thus obvious that in such a situation as this (groups III and IV) the customary view of the conditioned reaction as becoming linked to, and later evoked by, a previously inadequate stimulus, the conditioned stimulus, needs modification The evidence, taken from the comparative stabilities of groups I and III, and III and IV, points to a relationship between the conditioned response and another reaction system, in this case the hand response

The difference between I and III must indicate that the hand movement provides a reaction system into which the conditioned response may be integrated as it develops. That the conditioned response stands in a closer relationship to the movement of the hand than it does to the tug, as the conditioned stimulus, is definitely shown by the results obtained with group IV[21]

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[21] It might be added that there was no check on the completeness of the inhibition of the hand response, the subject's report that the hand and arm were passive was taken at face value It is possible that a sensitive recording device, attached to the forearm musculature, might have shown small incipient movements persisting through the first few tests, especially in the case of Wing, whose conditioned response was the most stable in this group

Hilgard and Marquis (4) reported a positive relation between ease of conditioning and rapidity of extinction, whereas Bernstein (1) found the former value correlated with stability. Figures 3 and 4 show that, in the present study, ease and rapidity of conditioning are correlated with stability. This corroborates Bernstein's findings under different experimental conditions.

The Responses of the Hand and Lid. If the movements of the hand and lid are coordinated during the training period, one should expect to find a close temporal relationship between the two. The data for group III, where such a coordination is suggested, are summarized in Table 3, and graphically represented in Figure 5.

TABLE 3

AVERAGE TEMPORAL DISPARITY BETWEEN LID AND HAND DURING TRAINING PERIOD FOR GROUPS II AND III (VALUES IN SIGMA)

Group	Subject	Disparity	A D	Group	Subject	Disparity	A D.
II	Ruck	49	34	III	Guth	41	23
	Tur	67	34		Cur	41	27
	Har	65	48		Ebe	42	24
	Sha	55	28		Hei*	16	12
	Sper	57	23		Ups	38	14
	Blec	33	19		Gal*	29	18
	Wms	65	56		Boy*	32	15
	Cap	89	55		Ben	49	17
	McK	78	61		Zor*	58	36
	McCl	38	20		Schr*	24	14
	Mean	60			Mean	37	

*Least stable conditioned responses from these subjects.

In order to determine the disparities it was necessary first to determine the lag of the key by means of which the shock was administered. that is, to determine the time elapsing from the beginning of the movement of the finger against the key to the closure of the shocking circuit as indicated by the signal magnet. This was done with eight subjects, and the lag, determined by measurement of 400 records, was found to be 45 sigma, the A D 6 sigma. For these readings the finger movement was recorded pneumatically from the bulge of the forearm muscles, and the key closure in the usual manner.

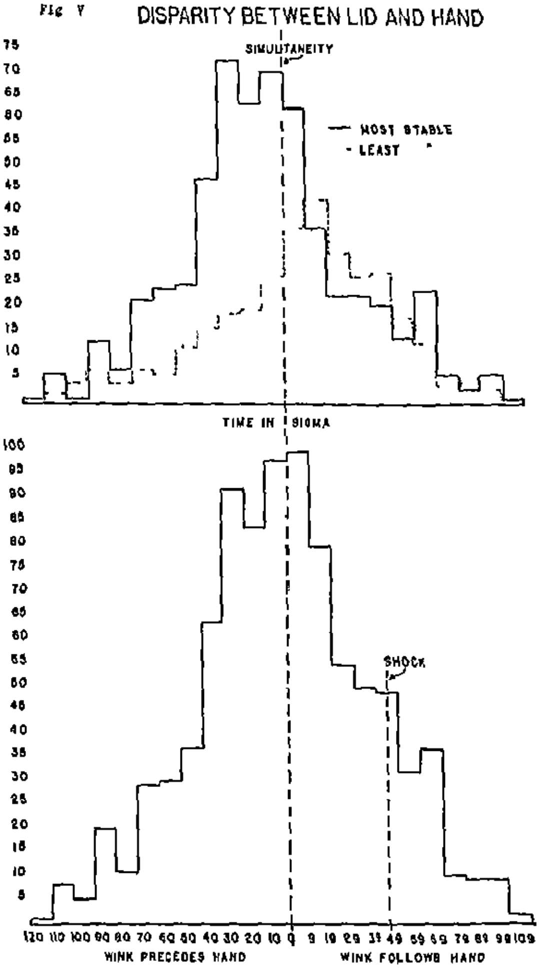

FIGURE 5

Table 3 gives the average time difference between hand and lid for each subject in groups II and III. For group III the range extends from 16 to 58 sigma, the average for the entire group is 37 sigma The variations from the averages of the subjects are seen

TABLE 4

VARIATION IN THE NUMBER OF CONDITIONED RESPONSES FOR DIFFERENT TEMPORAL RELATIONS BETWEEN LID AND HAND IN THE MOST STABLE AND LEAST STABLE SUBJECTS IN GROUP III

	Lid leads by	(time in sigma)									
Sub-groups	101- 110	91- 100	81- 90	71- 80	61- 70	51- 60	41- 50	31- 40	21- 30	11- 20	1- 10
5 most stable	*6*	*1*	*13*	*7*	*22*	*24*	*25*	*48*	*73*	*64*	*71*
5 least stable	2	4	7	4	7	6	12	16	19	20	27
M/L	3	25	1 9	1 8	3 1	4	2 1	3	3.8	3 2	2 6
	Lid follows by										
	0- 9	10- 19	20- 29	30- 39	40- 49	50- 59	60- 69	70- 79	80- 89	90- 99	100- 109
5 most stable	63	37	23	23	21	14	24	6	3	6	1
5 least stable	37	43	32	27	28	18	13	4	6	3	1
M/L	1 7	.9	65	85	71	8	1 8	1.5	5	2 0	1.0

to be considerable in relation to the averages themselves. It is noteworthy, however, that both the disparities and their variations are smaller for group III than for the first 10 subjects in group II.

Figure 5 shows that for group III as a whole (the lower curve) the distribution is normal, with a decided tendency for the lid responses to cluster about the hand movement in time; in general, tending to precede it by 10 to 20 sigma.[22]

The curves in the upper half of the figure show that when the group is divided into two subgroups, the five subjects whose conditioned reaction was most stable (above the mean) and the five whose reaction was least stable, there is a difference in their respective lid-hand relationships The most stable responses tend to lead the hand movement while the least stable tend to follow it This is also seen in Table 4 where the frequencies of both subgroups and their ratios, M/L, are indicated for each interval For the first 9 intervals with the lid in a leading position the ratio varies from 1.9 to 4 0; where the hand leads the lid, the ratios vary from 0.5 to 1.8. In the most stable subjects 63 per cent of the lid responses preceded the hand and 37 per cent followed, in the least stable group the ratios were exactly reversed, 63 per cent followed the hand, 37 per cent preceded The values for the interval between hand and lid for the two subgroups, when averages are treated without reference to direction of the difference, show no marked difference between the groups The value is in general smaller for the least stable (L) subjects

This last fact should serve to remind us that the temporal relations schematized and discussed on pp 423-424 are effective only within limits The time relationship may be an important factor in the greater stability of group III; but within this group individual variations in stability cannot be traced to this source.

Table 5 shows the time relations of hand and lid responses in successive 10 trials over the entire sitting The values for this table were obtained by calculating the median position of the conditioned

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[22] Of the 958 conditioned responses obtained in group III, 20 were not included because of imperfections in the recording which made it impossible to read them with reference to the key Of the remaining 938, all but 25 fell within the range of the distribution in Figure 5 The curve is therefore based upon 913 responses obtained from the 10 subjects in group III

TABLE 5

MEDIAN POSITION OF THE LID WITH RESPECT TO THE HAND IN SUCCESSIVE TEN TRIALS FOR TWO SUBGROUPS OF GROUP III

		Training					Testing										
	Stage	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	11
Most stable*	Guth	—35	— 5	—25	—40	—30	—35	—25	— 10	+20	+10	+45	+45				
	Cur	—20	—15	—40	—55	—10	—20	—10	+ 10	0	+45	+90	+45				
	Ebe	+55	+50	+10	—10	—45	— 5	— 5	— 30	—15	—15	—30	—25	0	—10	+15	
	Ups	—30	+45	+40	—30	—30	—15	— 5	— 10	—10	— 5	+ 5	— 5	—20	—15	0	+5
	Ben	+65	—30	—60	—45	—40	—35	—25	— 20	—25	—25	+35					
Least stable	Hei	—10	— 5	+10	+10	0	+30	+40	+100								
	Gal	+55	+ 5	— 5	—25	0	+30	—10	+ 85								
	Boy		+35	+35	+20	+25	+40										
	Schr	+25	+10	+20	+15	0	+10	+10	+ 35	+25	+50						
	Zor	—10	—55	—35	—65	—70	—20	—30	— 5	+25	+15						

*Extinction was not complete with any of these five subjects response relative to the hand movement for each 10 trials. Priority of the lid is indicated by a minus sign, whereas the plus sign indicates that the lid follows

The table shows that the most stable conditioned reaction tends to assume a leading position as training proceeds, while the least stable response shows no such tendency. In two of the five cases in the most stable group the lid reaction consistently led the hand (Guth and Cur); with Ebe and Ben the early lid responses followed the hand, while the later ones moved forward as the sitting proceeded, until, by the end of the training, they were leading by 40 and 45 sigma, with Ups the first conditioned reactions led the hand, the position then shifted back to +45 and from there forward to —30, which was maintained to the end of training In every case the value for the last 20 training trials indicates that the lid had come into a closely leading position.[23]

The other five subjects, with the least stable conditioned response, show different characteristics Two, Boy and Schr, failed to bring the lid into a leading position during the entire training period, although Schr shows an approximate simultaneity for the last 10 trials. In one case, Hei, there is a small disparity throughout training; the lid first leads, then follows, and ends in approximate simultaneity; but only in the early trials does it consistently lead. With Gal the early responses follow the hand, the later ones roughly approximate it Of this group only Zor shows the lid consistently leading the hand, and her stability was the highest of the five and very near the average value[24]

The results from the first half of Table 5 offer no difficulty in interpretation If the conditioned reaction is to be very stable (above the mean for group III) it must not only tend to approximate the hand movement as training proceeds, it must move into a leading position. Where it fails to do this, the stability is always less than 40 conditioned reactions; where it succeeds, the stability is always more than 40.

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[23] Of the 95 responses recorded on these 20 trials, 15 actually followed the hand, 12 of these by 5 to 20 sigma They were sporadic in appearance and, therefore, would not show in the medians They were divided among all five subjects.

[24] Cf Zor's stability of 43 with Ben's 55 There was some question in the mind of the experimenter regarding the completeness of extinction in Zor's case Toward the end of the testing period the conditioned response became a rise of the lid of such amplitude as to represent a distended opening The subject stated later that she had been "trying to see if I could stop winking"

The second half of the table is equally significant. The most stable group shows the lid leading during the early tests in every case. With Cur it slips back in the third stage, with Guth in the fourth, with Ben in the sixth, with Ebe in the tenth, and perhaps with Ups in the eleventh.[25] The same tendency is evident in the least stable group. The lid response invariably falls further behind the hand as it approaches extinction

Since in no case in the most stable group was extinction, as determined by our criterion, complete, the significance of the tendency of the lid response to fall behind the hand in this group will be clear only if it correlates with noticeable amplitude decrement of response. Therefore the responses of these five subjects were measured, and the results are presented in Table 6. The values in the table represent millimeters on the tracings.

TABLE 6

Amplitude of Unreinforced Conditioned Responses of the Most Stable Subjects in Group III for Successive Ten Trials

	Trials									
Subjects	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Guth	1.45	1.45	1.50	1.17	1.05	98	96			
Cur	1.80	1.70	1.30	.83	1.00	75	.82			
Ebe	2.08	2.13	2.47	2.17	2.18	2.00	2.08	1.88	91	75
Ups	1.80	1.90	2.00	2.08	2.10	1.85	1.75	1.73	1.50	1.33
Ben	1.88	1.70	1.20	1.30	1.25	97				

With Guth the greatest decrease in amplitude occurs during the fourth ten trials, and thus correlates with the shift of the response from leading to following position. With Cur the same is true; the greatest decrements are found in the third and fourth ten. With Ebe the greatest decrease falls in the ninth stage, and the temporal shift in the tenth. With Ben the temporal shift in the sixth ten trials is correlated with a sharp drop in amplitude. Ups shows a decrement in the sixth, ninth, and tenth stages; in the sixth and tenth his lid response fails to lead the hand

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[25] *Perhaps*, because none of the time readings is precise to less than five sigma.

Such results are not novel in the sense that it has been generally known that the latency of the conditioned response increases as extinction progresses [see, e g, Hilgard and Marquis, (4, p. 64)]. These shifts in the position of the conditioned response represent genuine increases in latency, because there was no concurrent decrement of the voluntary reaction time of the hand

Discussion of the Results

The method employed in group III, where a movement of the hand regularly precedes the administration of the unconditioned stimulus (shock) yields results which are significantly different from those obtained where no hand movement is involved. This is true with respect to rapidity of conditioning, reliability of the mean frequency (even for a small group of subjects), completeness of conditioning, and resistance to experimental extinction Where the hand movement is less closely and less regularly related to the reflex (group II) these differences are not so clear

Since the differences between groups II and III fall short of statistical reliability, except for completeness and consistency of conditioning, the functional differences between the self-administered and the mechanically administered shocks are not clear The failure to obtain reliable differences is due mainly to the atypical behavior of one subject in each group Therefore an extension of the series should settle the question.

Figure 3 indicates that group II does finally reach complete conditioning, although at the very end of the training period. Had this level of conditioning been maintained for a longer period, the conditioned response might have been more stable. In that case the temporal relations in group III could be looked upon as serving only to integrate the two movements of the hand and lid more rapidly than is the case in group II. That this may be the case is indicated also by the stability difference between I and II

The integration of the lid and hand movements in group III after 50 trials is such that when the hand movement is omitted from the testing period the lid movement is extinguished almost immediately. The results obtained from group IV leave no doubt of the fact that the continuation of the hand movement is vital to the stability of the conditioned response. This must mean that *the conditioned stimulus (tug) and the unconditioned reflex (wink) have not been linked* by the paired presentations. In the first place, the conditioned wink is clearly a different movement from the reflex wink to shock. Secondly, the stability of group IV was the lowest obtained. These are two excellent reasons why the Pavlovian formula for the conditioned response does not represent correctly the facts of conditioning.

The results obtained from groups III and IV indicate that *the two movements*—flexion of the hand induced by command, and a modified form of the lid response—*have been linked,* and in such a way that the lid gradually comes to lead the hand. This is shown in Tables 3, 4, and 5, and in Figure 5 There is a further indication of such linkage in the manner in which the conditioned response "follows" the hand movement in certain special instances

This experiment involves a reaction-time situation in one respect, namely, that the subjects in groups II, III, and IV acted under instructions to press the key immediately upon stimulation by the tug. It is occasionally found in reaction-time experiments that the subject's set to react spills over into an anticipatory response This phenomenon of "jumping the gun" was occasionally found in some of the subjects who served in this experiment. Twenty-one subjects pressed the key before being stimulated by the tug, 82 times in all In 74 instances the lid movements came forward with the hand

Conversely, some subjects occasionally reacted very slowly In group II the shock would intervene if the latency to the tug was more than 400 sigma. This very long reaction time was found in group II for 14 reactions. On 10 of these occasions there was no conditioned reaction, because the delayed hand response also delayed the lid movement until the shock was administered, and the lid was closed when the hand movement occurred In the other four trials the lid movement was closely related to the hand movement in time. In group III this long reaction time was observed five times, and the lid reaction was concurrently delayed every time

As has already been stated, the lid response is not linked to the tug stimulus in the situation of groups III and IV. This fact casts light on one of the basic difficulties so far encountered by the conditioned response explanation of learning, namely, the difficulty of conditioning and the rapidity of extinction. Schlosberg (14) has pointed out that under the customary conditions in conditioning experiments, "the conditioned knee-jerk seems to be a bit of behavior more or less broken off from our usually integrated patterns" Further, he states that.

> When we are working with the skeletal-muscle responses of human beings, most of our efforts are devoted to breaking off the stimulus-response sequence from the rest of their behavior, lest the conditioned response formed be called "voluntary" This may explain why it is so difficult to set up a conditioned response such as withdrawal from shock, knee-jerk, wink, etc, in adult human subjects (p. 337)

The situation in group I is in many ways similar to that ordinarily employed in conditioning work The main difference lies in the fact that the multiple stimulation tends to enhance the conditioning In groups II, III, and IV, however, the subjects were provided with well-learned activities, which in no way interfered with the conditioning, but, on the contrary, provided a behavior context into which the conditioned responses could be integrated. The effect of such provision is very clear When the conditioned response is permitted to become a part of the behavior of the subject, coordinated with an activity of the entire organism, instead of being forced to remain an isolated and momentary "fraction of behavior," it appears readily and with great frequency, and remains unusually resistant to extinction.

The procedure followed in this experiment involves the employment of a prescription, an *Aufgabe*, and this is a feature which is invariably present in any learning situation, and traditionally absent from the routine conditioning experiments The subject is here assigned the task of responding regularly to a specific stimulus. His response under these conditions is more than a simple flexion of the fingers of one hand The instructions bring the muscles of the eye, neck, arms, trunk, and legs into a posture which regularly culminates in the hand movement and provides an action context into which the conditioned responses are integrated

SUMMARY

1 The conditioned lid response differs from the reflex response in latency and form The two reactions may be differentiated on the basis of the muscular action in each.

2. Under the present experimental conditions the conditioned wink develops very rapidly and reaches maximum frequency by the end of 25 trials

3. Under these conditions there is no correlation between ease of conditioning and rapidity of extinction The method which yielded the most rapid acquisition of the conditioned response also gave the greatest stability.

4. When the subject regularly responds to the conditioned stimulus with a "voluntary" reaction which is closely related to the lid reaction, the conditioning is very complete, the usual variation between individuals is reduced, and the conditioned response is unusually stable

5. When the relation between the two *movements* is less regular, the frequency is more variable and the conditioned response may be less stable. On the other hand, the fixity of the interval between the conditioned and the unconditioned *stimulus* does not appear to be important.

6. When no voluntary movement is employed, the conditioned response appears least frequently and is very unstable

7 In the group in which the shock was self-administered the conditioned responses were clustered about the hand movement. The more stable responses tended to precede the hand by a slight interval (from 10 to 50 sigma at the end of the training series).

8. The temporal relations in this method are effective only within limits Within the group the individual differences are not to be explained by variations in the synchrony between the hand and the lid.

9. There are several indications that the movements of the hand and the lid are linked together When the hand response precedes the signal (tug), it carries the lid response forward with it. Conversely, when it is abnormally retarded, the lid response is also delayed. When the hand movement is employed in the training period and inhibited during the tests, the conditioned response, although fully developed, is very rapidly extinguished

10. Viewed as a whole the experimental results challenge the Pavlovian interpretation and provide an explanation for the divergence between the findings for the conventional conditioning experiment and the well-established facts of learning.

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A STATISTICAL ANALYSIS OF RATIONAL LEARNING PROBLEMS*

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I. INTRODUCTION

Rational learning is defined by Peterson (14) as learning which involves the mastery of puzzles and problem boxes. It is contrasted with learning which is largely the effect of practice,

> such as typewriting, telegraphy, ball-tossing, memorizing nonsense syllables, and so on. . Some of these learning processes are clearly concerned only with the acquirement of skill, little organization of conscious selection of any sort being required. Another type of learning has to do largely with the mastery of puzzles, problem boxes, and mazes. In some of these cases the situation remains unchanged in its essential features during the attempts at the solution of the problem; in others the situation to which the learner is reacting changes with the different reactions. In this general group of problems one successful solution may be sufficient to reveal the steps to be taken, so that subsequent efforts are practically perfect, or the relations may be so intricate as to require a series of successive trials for a perfect score

Rational learning is looked upon as purposive thinking in which ideas are used in the effective solution of a problem

Peterson refers to his Rational Learning Test as a memory reason test in which the subject is to use all the mental powers at his command (14) In this test, a series of numbers and letters are to be associated correctly. There is no doubt that this test permits the use of rational behavior, but it is not at all certain that the subject actually avails himself of this opportunity. One can learn the correct order of the numbers without regard to the associated letters by means of a purely "hit and miss" system. It is possible,

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however, to overcome this criticism by changing the order of presentation of the letters. By these means, the subject is forced to associate the letters with the numbers, and the attempt to learn purely by trial and error is quite futile. This procedure has been used by McGeoch and Oberschelp (12).

A more pertinent source of error in Peterson's Rational Learning Test arises from the fact that the time is a function of the test administrator and not alone dependent upon the subject. In the usual procedure the examiner calls out the letter, and the subject responds with the number which he believes is paired with this letter. It is apparent that the examiner may cause gross fluctuations in the time required for learning. An attempt has also been made to overcome this objection Haught (3) described an apparatus which he used to administer the Rational Learning Test and which eliminated the experimenter's rôle.

II. PROBLEM AND APPARATUS

1. *Problem.* This investigation is a statistical analysis of results obtained with rational learning problems.[1] The analysis will attempt to answer the following questions.

1. What is the correlation between the two scores yielded by the problems (time score and total bolts score)?
2. What is the relationship of the problems to each other?
3. What is the correlation between the problems and other mental abilities?
4. What is the multiple correlation between the problems as a battery and the other abilities?
5. What factors operating in the problems and the mental abilities are responsible for the correlations obtained?

2. *The Apparatus.* The apparatus designed by Max (11) was originally based upon a simpler board used by Haught (3); but whereas Haught's board was primarily a test of memory, the present apparatus shifted the chief emphasis to the reasoning factor (11). It consisted of a box on the front of which were the heads of 100 steel bolts numbered from 1 to 100 Only these bolts, placed upon

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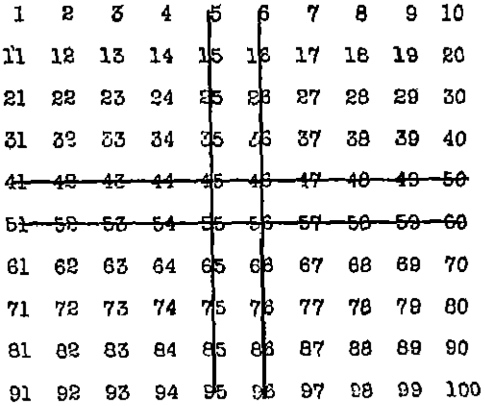
[1] These problems are a test of rational learning devised by Professor L. W. Max

a background of black, and one additional sample bolt set off by itself in the lower right corner of the box, were visible to the subject. Inside the box, the bolts were wired into two separate circuits. One circuit included an electric bell; the bolts forming this circuit were arranged in a familiar pattern or design, which might be a letter of the alphabet, a number, or a geometrical figure. Any of these bolts when touched by the stylus caused the bell to ring These bolts are referred to as the "bell bolts." The other circuit included the remaining indifferent bolts which formed the background of the pattern. These bolts are referred to as the "other bolts." Each circuit included a magnetic counter which recorded the number of bolts touched by the stylus. There were five boxes, each providing one problem, and in one experimental period a subject worked on all of them.

The task was (*a*) to discover those bolts which caused the bell to ring, (*b*) to discover the relationship existing between these bolts, (*c*) to recognize the pattern, and (*d*) to report the conclusions to the experimenter. Enumeration or mere pointing to the correct bolts was not enough The subject was required to "see or understand" the scheme or arrangement underlying these bolts and derive a meaningful figure or relationship. The performance was timed by a stop watch.



1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
~~41~~	~~42~~	~~43~~	~~44~~	~~45~~	~~46~~	~~47~~	~~48~~	~~49~~	~~50~~
~~51~~	~~52~~	~~53~~	~~54~~	~~55~~	~~56~~	~~57~~	~~58~~	~~59~~	~~60~~
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

FIGURE 1

PATTERNS IN EACH SERIES AND BOLTS COMPOSING EACH PATTERN

3. *The Patterns.* Three series of patterns were used in this experiment Each series was composed of five problems The first pattern in Series I, a large double cross, is graphically shown in Figure 1. The remaining patterns were similarly arranged. The bolts composing each pattern are shown in the following tabulation.

Pattern	Bolts
	Series I
A. A large double cross	5, 15, 25, 35, 45, 55, 65, 75, 85, 95, 6, 16, 26, 36, 46, 56, 66, 76, 86, 96; 41, 42, 43, 44, 47, 48, 49, 50, 51, 52, 53, 54, 57, 58, 59, 60
B Four right triangles, one in each corner	1, 2, 3, 4, 11, 13, 21, 22, 31, 7, 8, 9, 10, 18, 20, 29, 30, 40, 61, 71, 72, 81, 83, 91, 92, 93, 94, 70, 79, 80, 88, 90, 97, 98, 99, 100
C. An arithmetical progression 1, $(+2)=3$, $(+3)=6$, $(+4)=10$	1, 3, 6, 10, 15, 21, 28, 36, 45, 55, 66, 78, 91
D The letter "S"	19, 8, 7, 6, 5, 4, 3, 12, 22, 32, 43, 44, 45, 46, 47, 48, 59, 69, 79, 89, 98, 97, 96, 95, 94, 93, 82.
E' The number "4"	17, 26, 27, 35, 37, 44, 47, 53, 54, 55, 56, 57, 58, 67, 77, 87.
	Series II
A, *B*, *C*, *D* same as above	
E". The number "12"	12, 22, 32, 42, 52, 62, 72, 26, 17, 18, 29, 39, 48, 57, 66, 76, 77, 78, 79
	Series III
F. A Square	12, 13, 14, 15, 16, 17, 18, 19, 22, 29, 32, 39, 42, 49, 52, 59, 62, 69, 72, 79, 82, 83, 84, 85, 86, 87, 88, 89.
G Four rectangles one on each side	4, 5, 6, 7, 14, 15, 16, 17; 31, 32, 41, 42, 51, 52, 61, 62; 39, 40, 49, 50, 59, 60, 69, 70; 84, 85, 86, 87, 94, 95, 96, 97.
H. An arithmetical progression, 1 $(+2)=3$; $(+2)=5$, $(+3)=8$; etc.	1, 3, 5, 8, 11, 15, 19, 24, 29, 35, 41, 48, 55, 63, 71, 80, 89, 99
I The letter "G"	38, 27, 26, 25, 24, 33, 43, 53, 63, 73, 84, 85, 86, 87, 78, 68, 58, 57, 56
J The number "81".	13, 14, 22, 25, 32, 35, 43, 44, 52, 55, 62, 65, 73, 74, 27, 18, 28, 38, 48, 58, 68, 78, 77, 79

III PROCEDURE

1. *Experimental Procedure.* In each experimental period the subject solved the five problems constituting a series. Each problem was timed separately and the length of the experimental period was determined by the speed with which the problems were solved. A maximum of seven minutes was allowed on each problem. At the end of the fifth problem, the subject introspectively reviewed his work

Before the subject knew anything about the nature of the experiment, he was orally instructed as follows·

> The first thing I want you to do is to take this stylus and touch each of these bolts from 1 to 100 in this manner. (Experimenter demonstrated) Work from left to right.

During this activity, the box was not connected into the electric circuit. The subject, then, sat down, faced the apparatus, and read the following instructions

INSTRUCTIONS

> Do you know anything about this experiment?
> Please cooperate with me and do exactly as I tell you Above all, do this test seriously, as this is a research experiment
> In the apparatus before you, there are 100 bolts arranged in ten rows of ten bolts each. Of these hundred bolts, a definite number have been connected with a bell in such a way that when they are touched with a stylus, the bell will ring This sample bolt, for example, is similarly connected, and when I touch it with the stylus you notice it rings[3]
> The bolts which ring the bell have been chosen, not haphazardly but in accordance with a definite scheme; there is a definite relation among them They might form a *letter of the alphabet, a geometrical pattern, a number;* or the *scheme might be a mathematical one,* involving a relation between the numbers on the bolts Your task is to begin at number 1 and discover the underlying scheme or relation in the ***shortest possible time*** You will have to explain this scheme or relation satisfactorily to me, either by naming it or by describing it. Mere enumeration of the individual bolts which ring the bell will

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[3] The experimenter demonstrated.

> not be accepted as a solution *As soon as you have a "hunch" as to the scheme or relation, tell me immediately Remember the shorter time you take, the better is your score*
> Then as a check, you will have to run through the scheme for me, once without error, that is, you will have to touch each bolt that rings the bell, omitting those which do not.
> *Make sure you understand these instructions before starting. Reread them carefully*

After the completion of the first problem in a series, oral instructions were given before the beginning of the next problem in order to prepare the subject for the type of pattern to be discovered. These directions were:

> For problems *B* and *G:* "The next is also geometrical." (*A* and *F* would already have been solved and given geometrical names, a cross, and a square.)
> For problems *C* and *H* "The next is a numerical scheme. There is an arithmetical relation between the numbers on the bolts which ring the bell"
> For problems *D* and *I* "The next is a letter of the alphabet"
> For problems *E* and *J* "The next is a number greater than nine." (For problem *E*′ of Series I the instructions were simply: "The next is a number.")

The test performance consisted of two parts, the solution and the check Time and total number of bolts touched were recorded separately for the solution and for the check, and also for each incorrect hunch or solution offered by the subject.

At the completion of the entire series, verbal reports were made by the subject, in accordance with the following instructions.

> I would like you to tell me all about the experiment What were you doing? What did you think about? Anything that you think would help me in understanding your behavior is valuable. Begin with the first one, the cross.

2. *The Subjects.* Two groups of students in the University College of Arts and Pure Science, New York University, all men, served as subjects in this experiment during the course of two years. Group I was composed of 62 students in the elementary course in Psychology during 1932-33. This group took Series I. Group II was composed of 87 students in the elementary course in Psy-

chology during 1933-34. This group took Series II and III. There was an interval of three months between Series II and III. There were 40 sophomores and 22 juniors in Group I, and 62 sophomores, 23 juniors, and 2 seniors in Group II

3. *Measures of Mental Abilities* In the effort to determine the relationships between the problems and other measures of mental abilities, the following data were collected.

GROUP I

1 Scholarship Average for first two years.
2 Army Alpha (Form 7).
3 Otis S. A. Test of Mental Ability. Higher examination (Form A)
4 Stenquist Mechanical Aptitude Test I.
5 Syllogism Test (Max)
6. Thurstone Personality Schedule
7. Mathematics Content (Freshman Entrance, N. Y. U.).
8 Revised Minnesota Paper Form Board, Series A and B

GROUP II

1 Scholarship Average for first year.
2 Otis S. A Test of Mental Ability Higher examination (Form A)
3 Henmon Nelson Test of Mental Ability (Form A)
4 English Content II (Freshman Entrance, N. Y U)
5. Mathematics Content (Freshman Entrance, N. Y. U.).
6 Revised Minnesota Paper Form Board, Series A and B.

English Content II and Mathematics Content were tests given to all students applying for admission to the Heights Colleges of New York University. The former is a test of knowledge of grammar, spelling, and punctuation. The latter includes arithmetic, algebra, trigonometry, and geometry These two tests may be considered measures of achievement in these fields Max's Syllogism Test is a collection of specially chosen syllogisms and syllogistic statements[8] The statements are either true or false, and the score is the number right This test is a power test of ability to solve syllogistic problems.

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[8] The following is an illustrative item. "The people of the country are suffering from famine, and as you are one of the people of the country you must be suffering from famine."

The Revised Minnesota Paper Form Board Test (10) used in this experiment has a correlation of 80 with the original test developed by Paterson *et al.* (13). This test was administered under two sets of conditions. Group I was given the test as ordinarily administered with a time limit of 12 minutes. Group II was given the test as a power test with unlimited time Both forms, A and B, were administered. One-half the students in Group II took form A first and Form B second, the other half did the reverse

IV RESULTS

1. *The Relation Between the Time Score and the Total Bolts Score.* In maze learning and problem box experiments an arbitrary criterion of learning is usually established, as, for example, three consecutive errorless trials (6) This plan is also followed in nonsense syllable learning The procedure has been carried over into learning experiments involving higher mental processes. Peterson (14) required two consecutive errorless trials in his experiment. Heidbreder (4) required her subjcts to give four correct responses after stating the correct rule for solution Kuo (9) and Hull (7) used the criterion of one errorless series in their experiments upon concepts. In this experiment, one errorless check of the pattern was required as evidence of complete learning. Two scores were obtained for each problem, the Time and the Total Bolts. Time refers to the time in seconds required for the Solution-plus-Check, and Total Bolts to the number of bolts touched during the Solution-plus-Check

Time and Total Bolts would be expected to correlate perfectly if the problems were measures only of the physical activity involved

TABLE 1

CORRELATIONS BETWEEN TIME AND TOTAL BOLTS SCORES
Solution-plus-Check

Group I	Series I	N = 56 — 60	Group II	Series II	N = 77 — 86
	r	P E		r	P E
A	67	.05	*A*	.58	05
B	70	05	*B*	.80	03
C	75	04	*C*	83	.02
D	.74	04	*D*	76	.03
E'	.90	02	*E''*	.83	.02
Mean	75		Mean	76	

in touching the bolts The mean correlation between Time and Total Bolts is .75 for Series I and 76 for Series II (Table 1). Although the relationship between Time and Total Bolts is high, the evidence from the coefficients is that time is consumed when no bolts are touched with the stylus, and that the rate of tapping is not constant or regular. One, watching a subject at work on the problems, would observe the same irregularity of tapping and the relatively long pauses. The results indicate that some mental function or functions are present, the influence of which upsets the perfect relationship between Time and Total Bolts that would otherwise be obtained

2 *Relationship Between the Problems.*

Intercorrelations between the problems in each series. Table 2 includes the intercorrelations between the problems in each of the three series It is recalled that Group I took Series I, and that Group II took Series II and Series III. The mean intercorrelations between the problems for Series I are .32 (Time) and .39 (Total Bolts) For Series II these means are .45 (Time) and .46 (Total Bolts). For Series III these means are .50 (Time) and 52 (Total Bolts). The intercorrelations between the problems in Series II are more reliable than those of Series I, and those of Series III are most reliable In Series I only 10 of the 20 coefficients may be considered reliable. In Series II only one is not reliable. In Series III all are reliable. The interpretation and comparison of the results obtained with the three series of problems are complicated by the facts that Group II is larger than Group I, and that Group II had already had practice on Series II when it took Series III.

These intercorrelations may be compared with correlations obtained in maze learning and in Peterson's Rational Learning Test. Heron (5) reported the average intercorrelation of scores in five stylus mazes to be .34, .29, and .34 for trials, time, and errors, respectively. Higher correlations have been reported between different forms of Peterson's Rational Learning Test Garrison (2) found correlations of .75 (time), .60 (repetitions), and 70 (errors) between two different forms

Correlation between Series II and Series III. The sum of the

TABLE 2
INTERCORRELATIONS BETWEEN THE PROBLEMS

Group I Series I N=53-58*

Problem	*A* *Total bolts*	*B* *Time*	*C*	*D*	*E′*
A		19 (10)**	01 (09)	.31 (.08)	09 (09)
B	.25 (.09)		55 (06)	74 (05)	25 (09)
C	29 (08)	53 (.07)		64 (.05)	14 (09)
D	.40 (.08)	.70 (.08)	52 (07)		.28 (.08)
E′	00 (09)	42 (.08)	.38 (.08)	.41 (.08)	

Mean r = (Total Bolts) .39
Mean r = (Time) .32

Group II Series II N=71-84

Problem	*A* *Total bolts*	*B* *Time*	*C*	*D*	*E″*
A		33 (07)	.31 (07)	.20 (.07)	36 (.06)
B	29 (07)		.60 (05)	60 (05)	.61 (.05)
C	43 (.06)	.50 (.06)		35 (07)	.52 (.06)
D	.32 (06)	.56 (.05)	42 (07)		.56 (05)
E″	40 (06)	55 (.06)	.50 (06)	63 (05)	

Mean r = (Total Bolts) .46
Mean r = (Time) 45

Group II Series III N=67

Problem	*F* *Total bolts*	*G* *Time*	*H*	*I*	*J*
F		53 (.06)	.28 (.08)	46 (07)	.54 (06)
G	.46 (07)		63 (05)	.58 (03)	.64 (.05)
H	.39 (07)	40 (.07)		41 (.07)	46 (07)
I	.52 (06)	.56 (06)	61 (.05)		.46 (07)
J	.51 (.06)	54 (06)	.58 (05)	58 (05)	

Mean r = (Total Bolts) .52
Mean r = (Time) .50

Series II vs Series III N=67

	Time	*Total bolts*
A vs *F*	35 (07)	25 (.08)
B vs. *G*	43 (07)	38 (07)
C vs *H*	39 (07)	36 (.08)
D vs *I*	.40 (.07)	.43 (.07)
E″ vs. *J*	69 (.05)	.61 (06)
Mean =	45	41
Σ (*A*-*E*) vs. Σ (*F*-*J*) =	67 (05)	65 (.05)

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*In the statistical treatment of the data, the number of cases is less than the total N and varies from problem to problem. There are several reasons for this. Data were discarded where the subjective report revealed that the controlled conditions were not maintained. If the subject misunderstood the instructions, or deliberately disobeyed them, the results were not used Furthermore, a reduction in the number of cases occurred where other data were not available

**The figures in the parentheses represent the probable errors.

time scores for the five problems in Series II was correlated with the sum of the time scores of the five problems in Series III. This was also done with the Total Bolts Scores These correlations are respectively .67 and 65. A three-months interval elapsed between these two series The individual correlations between the patterns of Series II and Series III (that is *A* vs. *F*, *B* vs *G*, etc) are lower, averaging .45 (Time) and 41 (Total Bolts). These results are also included in Table 2 These coefficients may be compared with the correlations obtained in maze and nonsense-syllable learning on humans in which a time interval elapsed between first learning and further learning. Hunter and Randolph (8) report the foot-rule correlations of 49 (Time) between the first six trials in a maze and the second six trials with an interval of 159-161 days. In a similar situation with nonsense-syllable learning by the paired-associates method with an interval of 56-61 days, they obtained a foot-rule *r* of .58 between the first six trials and the second six trials. These correlations are only slightly higher than the intercorrelations between the rational learning problems in this experiment.

3. *Relation between the Problems and Other Measures of Mental Abilities*

Zero order correlation. Table 3 gives the coefficients of correlation between each problem and each of the other abilities for Group I Table 4 presents the same data for Group II. Since the scores on the problems were the time required and the bolts touched, the lower the score the better was the performance. In all the other tests used, the low scores indicate poor ability. To prevent confusion, correlation coefficients presented here have been reversed in sign. A positive coefficient now indicates that good performance in one ability is correlated with good performance in the other ability.

Relation to intelligence. Column 2 (Table 3) presents the correlation of the Army Alpha scores with Series I. The correlations between the problems and the Army Alpha Intelligence Test range from .18 to .46 The coefficients of correlation with the Otis Test are found in Column 3 of Table 3 Problem *C* is conspicuous because of its relatively high correlation with this test, .71 (Time) and .58 (Total Bolts) For Group II, the correlations with the Otis and Henmon Nelson tests of intelligence are tabulated

TABLE 3

Correlations Between the Problems of Series I and Other Abilities*
Group I

Problem	1 Two-year scholarship	2 Army Alpha	3 Otis S A	4 Math content	5. Stenquist I	6 Thurstone personality	7 Syllogism test	8 Revised Minn Paper Form Board
				Time				
A	.28 (08)	.46 (07)	06 (11)	14 (10)	18 (09)	—08 (11)	.00 (10)	37 (.11)
B	09 (09)	39 (09)	15 (12)	—14 (10)	.17 (09)	28 (11)	31 (.10)	70 (.08)
C	16 (09)	.31 (08)	71 (06)	20 (10)	11 (09)	09 (11)	.49 (07)	.42 (.11)
D	08 (09)	28 (.08)	.20 (11)	08 (10)	12 (09)	09 (11)	.25 (09)	58 (08)
E′	11 (09)	.19 (09)	01 (11)	48 (.08)	—.01 (09)	—14 (11)	17 (.09)	13 (13)
N	49-54	47-57	32-37	46-47	47-54	28-37	41-49	22-28
				Total Bolts				
A	.23 (09)	34 (08)	.07 (11)	29 (09)	03 (09)	—16 (11)	04 (10)	.33 (11)
B	.18 (.10)	43 (08)	29 (.11)	01 (11)	—07 (09)	.24 (.12)	.41 (09)	38 (.13)
C	07 (10)	.26 (08)	55 (.08)	30 (09)	—17 (09)	10 (11)	41 (.08)	02 (.13)
D	11 (.09)	27 (08)	08 (11)	19 (09)	—.21 (09)	—13 (11)	.23 (09)	04 (12)
E′	03 (.10)	.18 (.09)	13 (11)	35 (09)	—14 (09)	15 (12)	19 (10)	.08 (13)
N	49-53	46-57	31-35	44-46	47-53	28-36	40-48	22-28

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*For example, the correlation between Army Alpha and Time on Problem *D* is .28 This figure is to be found in the upper section of the Table which is marked "Time," at the intersection of line "Problem *D*" with column 2, "Army Alpha." The figure just below the correlation (in parentheses) is the P E

TABLE 4

CORRELATIONS BETWEEN THE PROBLEMS OF SERIES II AND THE OTHER ABILITIES

Group II

Problem	1 First-year scholarship	2 Otis S A	3 Henmon Nelson	4 Math content	5 English content	6 Revised Minn Paper Form Board, A first	7. Revised Minn. Paper Form Board, B first
				Time			
A	03	.24	28	03	—07	03	—07
	(.08)*	(08)	(.09)	(08)	(09)	(.12)	(11)
B	—17	14	26	07	04	39	64
	(08)	(09)	(.09)	(09)	(09)	(.11)	(07)
C	.27	44	11	.25	—08	17	—04
	(.07)	(.07)	(09)	(08)	(.09)	(13)	(11)
D	00	.05	14	.08	00	36	35
	(08)	(.08)	(09)	(08)	(09)	(12)	(10)
E''	04	30	13	10	—01	29	54
	(08)	(08)	(09)	(08)	(09)	(.11)	(.08)
N	75-82	62-67	49-52	60-65	57-61	27-30	36-39
				Total bolts			
A	09	41	.27	22	04	22	10
	(07)	(07)	(08)	(08)	(09)	(12)	(10)
B	—10	17	12	20	.09	45	.60
	(08)	(08)	(09)	(08)	(09)	(11)	(07)
C	—14	.39	20	24	—02	20	.08
	(08)	(07)	(09)	(.08)	(09)	(.12)	(11)
D	—08	15	07	14	23	45	26
	(07)	(08)	(.10)	(08)	(.08)	(.10)	(.11)
E'	04	36	03	.33	10	34	35
	(08)	(07)	(.09)	(07)	(.09)	(.11)	(09)
N	75-81	62-67	50-53	62-67	56-60	26-30	36-19

*The figures in parentheses are the P E's for the coefficients above.

in Columns 2 and 3 (Table 4) The correlations with the Otis Test ranging from 05 to 44 are somewhat higher than were found for Group I, although Problem *C* in particular exhibits lower coefficients of correlation Only a low positive relationship is present between Series II and the Henmon Nelson Test.

Since problem *A* is the first of the series, the subject was faced with a new situation to which he had to adjust successfully. Such adjustment is usually thought of as being measured by intelligence tests.[4] Therefore, problem *A*, even though the easiest problem, would be expected to correlate positively with these tests An inspection of Tables 3 and 4 reveals that, of all the problems, problem *A*, Total Bolts Score, correlated second highest with the Otis Test (.41, Table 4), highest with the Henmon Nelson Test (.27, Table 4), and second highest with the Army Alpha examination (.34, Table 3) Similarly for the Time Scores, Problem *A* correlated highest with Henmon Nelson (.28, Table 4), highest with Army Alpha (.46, Table 3), and third highest with Otis (.24, Table 4). The correlation of Problem *A* with Otis, Group I, is inconsistent with these results.

Scholarship The relation of the problems to scholarship is low and unreliable In Group II half of the coefficients of correlation are small negatives These coefficients are found in Column I, Tables 3 and 4 The results for both groups are not strictly comparable because, for Group I, two years of Scholarship were used while, for Group II, only the First Year Scholarship was available. It must be kept in mind that Scholarship consists of many separate grades indiscriminately combined to yield a single average. Furthermore, Scholarship represents no one ability but is rather a result of several abilities and traits such as intelligence, interest, and industry. It is not surprising, therefore, to find these low and unreliable coefficients

Correlation with ability in Mathematics and English. The coefficients of correlation with the English Content Test were computed only for Group II This relationship is presented in Column 5, Table 4 No significant relationship exists. The relations existing with the Mathematics Content Examination (Column 4, Table 3 and Column 4, Table 4) are in general low and unreliable with the following exceptions. Problems *E'* and *E''*, the patterns of the figures "4" and "12," are the only problems which yield reliable correlation coefficients with the test. Three of the four coefficients may be considered reliable. .48± 08, 35± 09, .10±.08, 37±.47.

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[4] Binet's conception of intelligence emphasizes three characteristics, one of which is "the capacity to make adaptations for the purpose of attaining a desired end" (Terman, 15, p. 45).

Correlation with Stenquist I and the Thurstone Personality Schedule. An examination of the coefficients in Columns 5 and 6, Table 3, reveals that the correlations with these tests are all low and unreliable. There is no apparent trend for either a positive or negative relation

Correlation with the Syllogism Test. The correlation coefficients between this test and the problems are listed in Column 7, Table 3 Only three correlations are reliable, .49±.07, .41± 09, .41±.08, and these are between the Syllogism Test and Time and Total Bolts for Problem *C*, and Total Bolts for Problem *B*.

Correlation with the Revised Minnesota Paper Form Board Test The correlation coefficients between the problems and this test are shown in Column 8, Table 3 and Columns 6 and 7, Table 4. The results for the two groups are not strictly comparable because Group I took this test as a time limit test, and Group II took it as a work limit test. Problem *B*, the pattern of four triangles, correlates higher with this test than do any of the other problems. In so far as this test and the problems involve visual spatial features, positive correlation is to be expected The small number of cases is responsible for many of the unreliable coefficients and may also be a factor in the differences which are apparent in the results obtained with the Time Scores and the Total Bolts Scores.

Analysis of results by partial correlation[5] The analysis of the relationships between the problems and selected abilities was made in order to examine these relationships when various combinations of abilities were held constant. In Group I, the partial correlation analysis was applied to the correlations between the problems and the Otis Test, the Revised Minnesota Paper Form Board Test, the Syllogism Test, and Scholarship; and in Group II, to the correlations between the problems and the Otis Test, the Revised Minnesota Paper Form Board Test, the Mathematics Content Examina-

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[5] The computation of the partial correlation coefficients was greatly facilitated by the use of a graphic method devised by Wood (18) Checking these coefficients against machine calculation by the usual method revealed that the use of the graphic method introduced a maximum error of less than 01.

TABLE 5

Partial Correlation Coefficients Between the Total Bolts Scores of the Problems and Selected Abilities

Series I Group I
1. The Problems *A*, *B*, *C*, *D*, *E′*.
2. The Revised Minnesota Paper Form Board Test.
3. The Otis S. A. Test of Intelligence.
4. The Syllogism Test.
5. Two-Year Scholarship

Series II Group II
1. The Problems *A*, *B*, *C*, *D*, *E″*.
2. The Revised Minnesota Paper Form Board Test.
3. The Otis S A Test of Intelligence
4. Mathematics Content Examination
5. One-Year Scholarship

Problems	*A*	*B*	*C*	*D*	*E′*	*A*	*B*	*C*	*D*	*E″*
r12	33	38	.02	.04	.08	22	45	20	45	34
r12 3	34	36	08	.04	05	.11	43	10	43	34
r12 4	.34	28	—.13	—.05	03	23	47	21	.46	37
r12 5	33	.38	02	.03	08	20	51	25	50	37
r12 34	36	29	—11	—.03	—.01	10	41	10	.43	.34
r12.35	35	36	—08	04	.05	12	49	.18	.48	.40
r12.45	40	28	—15	—05	03	25	62	.39	59	.52
r12 345	.41	29	—15	—.05	—02	.12	47	.16	48	42
r13	07	29	.55	.08	13	.41	17	.39	.15	36
r13 2	.01	25	55	07	10	37	05	.36	03	.29
r13 4	.06	.12	42	—09	02	35	07	31	09	.21
r13.5	01	26	.56	.20	12	20	20	44	18	38
r13 24	07	.06	.40	.07	.00	.29	—10	.27	—10	.09
r13 25	—06	.22	55	.07	.10	37	10	42	08	33
r13 45	.07	.12	43	—09	02	.35	.07	33	01	22
r13 245	10	.06	40	.07	.00	31	—03	23	—18	.03
r14	04	41	41	23	.19	22	20	24	14	33
r14 2	—07	33	43	.23	17	23	23	25	17	36
r14.3	.00	.31	08	.25	.16	—02	.12	.03	06	.16
r14 5	—08	.38	.43	18	.20	20	28	35	.20	.39
r14 23	—08	23	10	25	13	01	.26	05	19	.25
r14 25	—22	27	45	.21	18	25	43	.42	36	51
r14 35	—10	30	15	24	20	—01	20	15	37	.24
r14 235	—22	.21	.19	23	14	04	47	.23	.38	.42
r15	.25	.18	.07	11	03	09	—10	—.14	—.08	—04
r15.2	25	.18	07	10	.03	02	—26	—.21	—.26	—16
r15.3	24	09	—12	09	—.03	—02	—16	—.26	—.13	—15
r15.4	26	—02	—16	.06	—.06	—01	—22	—34	—17	—23
r15.23	25	.11	—12	10	01	—05	—.27	—30	—.27	—.23
r15 24	.34	02	—.19	—.02	—05	—09	—44	—42	—40	—42
r15 34	.27	—05	—15	—.02	—11	—.02	—22	—.30	—17	—.23
r15 234	.33	—.01	—20	—.01	—04	—.05	—47	—37	—.42	—.41

tion and Scholarship Only the correlations between the Total Bolts scores and these abilities were analyzed.

The partial correlation coefficients between the problems and these abilities are presented in Table 5 It is not practical to try to summarize all of the information contained in these tables. However, some of the high spots will be pointed out.

1. In all instances but one, the relationship betwen the problems and Scholarship is reduced from a positive value to a negative value or from a negative value to a greater negative when the other abilities are partialed out Thus, the zero order and third order partial coefficients between Series I and Scholarship are respectively Problem *B*, 18 and —01, Problem *C*, 07 and —20, Problem *D*, 11 and —.01, and Problem *E*, .03 and —04 The zero order and third order partial coefficients between Series II and Scholarship are respectively: Problem *A*, 09 and —05, Problem *B*, —10 and —47, Problem *C*, —14 and —37, Problem *D*, —.08 and —.42, and Problem *E*, —04 and —41. The actual size of these partial coefficients is not to be considered with finality as expressing the true partial correlation, because it must be remembered the zero order correlations with Scholarship were not reliable However, it is the consistency of the net reduction of correlation or of the appearance of the negative partial correlations between the problems and Scholarship which merits mention

2 The correlation of the problems in Series II, Group II, with the Revised Minnesota Paper Form Board Test is, in general, maintained with small changes For example, the zero order and third order partial coefficients between Series II and the Revised Minnesota Paper Form Board Test are respectively· Problem *A*, 22 and 12, Problem *B*, 45 and 47, Problem *C*, 20 and 16; Problem *D*, 45 and 48, Problem *E″*, 34 and 42. The same may be considered in the case of Problems *A* and *B* of Series I, Group I

3 The correlaiton with the Syllogism Test is reduced when the other abilities are held constant, except for the relationship between this test and Problem *D*, $r_{14} = 23$ and $r_{14\,235} = 23$.

4. In general, the correlation with the Otis intelligence test is reduced when the other abilities are held constant However, Problems *A* and *C* in both series maintain their correlation with this test better than do the other problems

5 The correlations of Problems *B*, *C*, *D*, and *E″* in Series

II with the Mathematics test are materially increased when Scholarship and the Revised Minnesota Paper Form Board Test are partialed out These coefficients are respectively, Promlem *B*, 20 and 43; Problem *C*, .24 and 42; Problem *D*, 14 and 36, and Problem *E''*, .33 and 51. (*See r's 14 and r's 14 25*)

4. *Multiple Correlation between the Problems and the Abilities.* The multiple correlations indicate what the problems as a battery measure In Tables 3 and 4 appear some first order correlations between problems and abilities which are comparatively high For example, in Table 3 consider Army Alpha vs. *A* (Time) and Otis vs. *C* (Total Bolts). By combining the problems into a battery by means of multiple correlation, it is quite possible that these abilities could be predicted more accurately.

Toops has devised a means for approximating within 01 the actual multiple correlation between a battery of tests and a criterion. The coefficient, thus obtained, is known as the multiple ratio correlation coefficient. The statistical procedure is described in a monograph by Garfiel (1) The multiple correlations between Series I and the Army Alpha Test, the Otis Test, the Mathematics Content Test, the Syllogism Test, and the Revised Minnesota Paper Form Board Test were computed For Series II the multiple correlation with the Otis Test, the Mathematics Content Test, Henmon Nelson Test, and the Revised Minnesota Paper Form Board Test were computed.

TABLE 6

MULTIPLE RATIO CORRELATION BETWEEN THE PROBLEMS AND ABILITIES

Ability	Series I Group I		Series II Group II	
	Time	Total bolts	Time	Total bolts
Army Alpha	62	.56		
Otis	.81	.69	52	51
Henmon Nelson			.40	32
Mathematics Content	.63	.54	.30	.39
Rev. Minn Paper Form Board (Power)	.77	64		
Rev Minn Paper Form Board (Speed Form A first)			.45	.55
Rev. Minn. Paper Form Board (Speed Form B first)			92	.67
Syllogism Test	.52	.50		

An inspection of Table 6 reveals two sets of outstanding results. First, the multiple correlation coefficients of the problems of Series I with the intelligence tests indicate the extent to which these problems can be made into a battery to predict intelligence (.62, .56, .81, .69). The multiple correlations of the problems of Series II with the intelligence tests are lower (.40, .32, .52 and .51).

The second outstanding result is the multiple correlation of the problems with the Revised Minnesota Paper Form Board Test. In Group I, the multiple correlations are .77 and .64. In Group II, the multiple correlations range between .45 and .92. It is to be recalled that the Revised Minnesota Paper Form Board Test was given as a work limit test to Group I and as a time limit test under two conditions to Group II. This test has two forms, *A* and *B*. Thirty students in Group II took form *A* first and then *B*, about 37 took form *B* first and then *A*. The score on this test was the sum of the scores on the two forms. Since these forms are equivalent, the fluctuation in the size of the multiple correlations is most likely due to chance variations and the small number of cases involved. The true correlation can reasonably be expected to fall somewhere within these extremes. It is significant to note that multiple correlations as high as those which were obtained are found when the Revised Minnesota Paper Form Board Test is administered as a time limit (speed) or work limit (power) test.

5. *Multiple Factor Analysis.* In the attempt to reveal the factors responsible for the correlations between the problems and the other abilities, a multiple factor analysis was made. Thurstone (16) has devised a simplified procedure for determining the factor loadings which operate in a table of intercorrelations. The correlations between the Total Bolts scores and the measures of abilities for both Series I and Series II were analyzed and the results are tabulated in Table 7. The coefficients under the headings, Factor Loadings, I, II, and III, express the degree of correlation existing between the variable to the left and the factors. For example, the factor loading of .40 for Problem *A* and Factor I expresses the correlation to be expected between Problem *A* and a measure of Factor I if one were available.

Series I. For Group I, a factor (Factor Loading I) is present which operated positively in all the problems and in all the abilities

TABLE 7

FACTOR LOADINGS OBTAINED FROM THE INTERCORRELATIONS BETWEEN TOTAL BOLTS AND THE ABILITIES

		Series I Group I Factor loadings			Series II Group II Factor loadings		
	Variables	I	II	III	I	II	III
1	Problem *A*	40	15	—11	53	—13	.18
2	Problem *B*	72	41	33	57	—47	—03
3	Problem *C*	61	36	—06	.55	—35	33
4	Problem *D*	53	66	—06	59	—48	—01
5.	Problem *E′*	37	32	—.11			
6.	Problem *E″*				65	—44	.32
7	Two-Year Scholarship	.47	—29	—21			
8.	One-Year Scholarship				24	39	—.10
9	Army Alpha	80	—37	21			
10.	Otis S. A.	59	—.20	24	.68	36	.22
11.	Henmon Nelson				58	38	—18
12	Mathematics Content	48	—10	—66	60	56	.30
13.	English Content II				32	26	—11
14.	Stenquist I	—03	—26	—19			
15	Thustone Personality Schedule	07	—17	49			
16.	Syllogism Test	73	—37	—12			
17.	Rev. Minn Paper Form Board (Work limit test, Form A first)				62	—11	—.76
18	Rev Minn Paper Form Board (Time limit test)	47	—.22	22			

but the Stenquist Test. The influence of the factor loading in this test and also in the Thurstone Personality Schedule, for practical purposes, is negligible. This factor, highest in Problems *B*, *C*, *D*, Army Alpha, Otis, and the Syllogism Tests and practically negligible in the Stenquist Test of Mechanical Ability and the Thurstone Personality Schedule might well be conceived as an intelligence factor The positive operation of Factor II in the problems, and negative in all the other abilities, is interesting It is not clear what this factor is. Factor III operated positively only in Problem *B* In the other problems the factor loadings are very low and negative It is also difficult to determine what this factor is

Series II In this series Factor I is, in all probability, the same factor as Factor I in Series I It also could well be considered as an intelligence factor, the loadings in Otis and Henmon Nelson being 68 and .58. The loading of 60 for Mathematics is not surprising since in this experiment the correlation between Mathematics Content and Otis is .37 and with Henmon Nelson 51 One might question the identification of Factor I because of the loading of .62 for the Revised Minnesota Paper Form Board Test. However the Revised Minnesota Paper Form Board Test is also a measure of intelligence. In this experiment it correlates with Otis .28 and Henmon Nelson 63 The authors of the original Minnesota Paper Form Board point out that "this test itself is subject to the criticism that it is not as unique with respect to intelligence as are the other two surviving tests" (13, p. 300) Factor I operates more uniformly in all the problems in Series II than in Series I.

Factor II operated negatively in the five problems and the Revised Minnesota Paper Form Board, and positively in the remaining abilities Such a situation suggests that it may be a language factor. Factor III in Series II is also difficult to identify. Its heavy negative loading in the Revised Minnesota Paper Form Board Test is outstanding. This factor operated positively in problems *A, C, E,* and practically not at all in *B* and *D.* The factor analysis was carried out to the determination of only three factors Other factors exist, although it is true that each succeeding factor is a residual factor and is of less weight and importance

V Discussion and Interpretation

Intelligence. There can be little question of the fact that intelligence is an important factor in the solution of the problems Any particular concept about the nature of intelligence need not interfere with the recognition of its importance in the solution of these rational learning problems In planning this research, one aim had been to devise problems which would offer something which ordinary intelligence tests did not. On the contrary, the data indicate that there is much in common between the rational learning problems and the tests of intelligence The evidence in support of this observation beyond the mere fact of the positive correlation between the problems and tests of intelligence is twofold First, there are the multiple correlations between the problems and the intelligence tests Secondly, there is the presence of a common factor in the problems and the intelligence tests.

Spatial Factor. The multiple correlations with the Revised Minnesota Paper Form Board Test, both as a time limit (speed) test and a work limit (power) test emphasize the spatial characteristic of the problems The solution of the problems necessitates an understanding of the spatial or pattern relationships among the bolts The multiple correlation with the Revised Minnesota Paper Form Board Test as a work limit test indicates that the element of rapid adjustment to the tasks is not the most important in the positive correlation between this test and the problems.

Visual and Verbal Methods of Solution. The partial correlation analysis revealed a relatively high negative correlation between the problems and Scholarship In this analysis, the abilities represented by the Otis S.A Test, the Mathematics Content Examination, the Syllogism Test, and the Revised Minnesota Paper Form Board Test were partialed out This negative partial correlation indicates that some factor was present which contributed positively to the solution of the problems and negatively to Scholarship. Is it possible to discover what this factor is?

One hypothesis which would explain this negative partial correlation is that there are visual and verbal methods or habits of solving the problem. If this hypothesis is correct, we would expect.

> 1. That because of the nature of the problems "visualizers" would do better on the problems than "verbalizers."
> 2 That "visualizers" would be poorer in Scholarship than "verbalizers" since Scholarship and its measure of performance are almost entirely verbal.[9]

A verbal solution is one in which the subject achieved the solution by talking over to himself the relationships between the bolts. In such a solution, interpretation of the relationships between the bolts is present. For example, a subject may discover that a column of bolts, one below each other, rings the bell. He might recognize that this line represents a figure "1" or the side of a square, etc Or in another case, a subject may discover that there is a horizontal row of bell bolts beginning at the top bell bolt in the above-mentioned vertical column He might think to himself that these two lines are at right angles to each other It might be the beginning of the letter "E," or "O," or "F," or "B." On the other hand, a visual solution was one in which the subject recognized the pattern by picturing or getting a mental image of it There was an absence of the above reasoning out of the pattern. The subjective reports at the end of the experiment contained information from which it was possible to characterize the solutions to the problems as verbal or visual. Unfortunately this characterization was not possible in all of the cases because the reports were too meager and incomplete.

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[9] The subjects in this experiment were enrolled in a liberal arts college It is quite likely that if the subjects had been pursuing an engineering course involving considerable drawing, drafting, and descriptive geometry other results would have been obtained

Although Problem C involved no figure or design, there were reports too, that this problem was solved by visual means. There were reports of observation of the space between bell bolts The reports indicated that subjects noticed that the distance between successive bell bolts increased uniformly. Then, there would follow closer scrutiny of the numbers on the bolts with the discovery of the numerical relationship Such methods of solution were also classified as "visual solutions." Verbal solutions, on the other hand, were those in which the subjects looked for an arithmetical or geometrical progression, in which they subtracted the numbers on the bell bolts from each other, and in which they counted the number of bolts intervening between successive bell bolts.

Most of the solutions remain unclassified When the experiment was begun and as it progressed, there was no expectation or knowledge of such analysis. Consequently, the reports were not guided

TABLE 8

MEAN SCORES FOR VERBAL AND VISUAL SOLUTION

	Group I				Group II			
	Verbal		Visual		Verbal		Visual	
Problem	M	N	M	N	M	N	M	N
				Time				
B	246	9	160	15	197	24	155	22
C	236	21	147	6	120	12	124	17
D	268	9	173	16	193	18	182	19
E'	180	4	112	19				
E''					219	20	198	8
				Total bolts				
B	268	9	194	15	207	24	189	22
C	146	21	90	6	131	12	83	17
D	335	9	219	16	242	18	198	20
E'	235	4	147	19				
E''					232	21	204	8

so as to give information on this point. Table 8 contains the mean time and mean total bolts required for those who could be considered to have used verbal solutions and for those who used visual solutions of problems *B*, *C*, *D*, *E′*, and *E″*. Problem *A* was so simple that little was ever said about it, and thus the solution of this problem could not be classified

In every case but one, the mean score for visual solution is smaller than the mean score for verbal solution Because the number of cases was so small, the reliability of the differences was not ascertained. However, the consistency with which this superiority of the "visualizers" over the "verbalizers" obtains, and the size of the differences suggest that these differences are of significance. The only instance in which the "visualizers" have a larger mean than the "verbalizers" is the Time of Problem *C* for Group II In this instance the mean for "verbalizers" is 120 and for "visualizers" 124.

It is of interest to compare these results with results obtained by Warden (17) in an experiment upon stylus maze learning He found that the mean in trials to learn the maze by those who used a "word reaction" mode of attack (verbalization) was less than the mean for those who used a "visual imagery" mode of attack (visualization). These means were respectively 32 2 and 67 9 The comparison between these results brings out the importance of the nature of the problem in determining the efficiency of a method of solution

VI. SUMMARY AND CONCLUSIONS

1 Two scores were obtained, one, the time required for the solution plus the check, and two, the total number of bolts touched during the solution plus the check. The mean correlation between the Time Scores and Total Bolts Scores is .75 (Series I) and 76 (Series II)

2. The average intercorrelation between the Time Scores of the problems of Series I is 32, and .39 for the Total Bolts Scores. In Series II and III the average intercorrelation between the problems is higher In Series II for the Time Score it is .45, and for the Total Bolts Scores it is 46 For Series III, the average intercorrelation for the Time Scores is .50 and for the Total Bolts Scores .52

3 (*a*) Zero order correlation reveals the following relationships between the problems and the other abilities.

> Army Alpha correlated higher with Problem *A* and Problem *B* (46, 39[7] and 34, 43 respectively) than with any of the other problems The Henmon Nelson Intelligence Test has only a low correlation with the problems in Series II, the highest being with Problem *A* (28) Considering Time Scores and Total Bolts Scores for both Series I and II, the Otis S A Test correlated highest with Problem *C* (71, 55 and 44, 39) in both series
>
> The correlations between Scholarship and the problems are generally low positives and negatives Only two correlations are above .25 These are between Scholarship and Time Scores of Problem *A* in Series I (28) and between Scholarship and Time Scores of Problem *C* in Series II (27).
>
> Mathematics Content Examination correlated highest with the number patterns, Problems *E'* and *E''* of the problems in both series considering both the Time Scores and Total Bolts Scores (48, 35 and .10, 33).
>
> Mechanical Aptitude as represented by Stenquist I has very little correlation either positively or negatively with the series
>
> The Thurstone Personality Schedule also correlated low with the problems, positive with Problems *B* and *C* and negative with Problems *A*, *D*, and *E'*
>
> The correlations between the Syllogism Test and the problems are highest for Problems *B* and *C*, Time Scores and Total Bolts Scores (31, 41 and 49 and 41)
>
> English Content II has little correlation either positively or negatively with Series II
>
> The Revised Minnesota Paper Form Board Test correlated highest with Problem *B* of all the problems in both Series I and Series II (.70, 38 and 39, 45, and 64, 60) The Paper Form Board Test also has positive correlation with the Time Scores of Problems *C* and *D*, and the Total Bolts Scores of Problem *D*

(*b*) The partial correlation analysis revealed a negative relationship between the problems of Series II and Scholarship when the Otis Test, The Revised Minnesota Paper Form Board Test, and the Mathematics Test were partialed out A tendency toward negative correlation was revealed in the case of Series I, except for Problem *A* In Problems *A* and *B* of Series I and in all the problems of Series II the correlation with the Revised Minnesota Paper Form Board Test is generally maintained when the higher order partial coefficients are computed. The correlation of Problems *A* and *C* with the Otis Test is little affected by the application of partial correlation.

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[7] Whenever two coefficients are given in this manner, the first refers to the correlation for Time Scores, and the second for Total Bolts Scores

4 In general, higher multiple correlation is obtained between the problems and the intelligence tests and between the problems and the Revised Minnesota Paper Form Board Test than with any of the other measures of abilities. Larger multiple correlation with intelligence is found for Series I than for Series II. For Series I, the multiple correlations with Army Alpha are .62 and 56, and with Otis 81 and .69 For Series II, the multiple correlations with Otis are .52 and .51 and with Henmon Nelson .40 and .32 The multiple correlations with the Revised Minnesota Paper Form Board Test are for Series I .77 and .64 and for Series II 43, 55, .92, and .67.

5. The multiple factor analysis reveals a conspicuous factor operating in the ability to solve the problems and the variables represented by the other tests of abilities except Stenquist I and the Thurstone Personality Schedule in which this factor has for practical purposes a zero loading. Factor II operated positively in the problems of Series I and negatively in the other abilities. Factor II operated negatively in the problems of Series II and the Revised Minnesota Paper Form Board Test, and positively in the remaining abilities. Since there are different tests in each group, Factors II and III, the group factors, are probably not the same, and the reversal in signs for Factor II is difficult to interpret. The analysis was carried out to the determination of only three factors.

6 The satistical analysis of the results obtained with the rational learning problems in this experiment brings out three important conclusions.

> 1. Intelligence, as measured by the intelligence tests used, is an important factor in the ability to solve these problems.
>
> 2. An element of a spatial pattern and relationship as measured by the Revised Minnesota Paper Form Board Test operates in the problems.

3 The hypothesis was suggested that there may be two methods of solution, a verbal and a visual, and that the visual method is the more efficient

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SHORT ARTICLES AND NOTES

TIME TAKEN BY EYE-MOVEMENTS IN READING[1]

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The time taken for fixational pauses plus that for eye-movements yields the total reading time for any selection. It is well known that no clear vision occurs during the eye-movements in reading, that a very large proportion of the total reading time is devoted to fixational pauses, and that perception occurs during these pauses. Although the nature of the fixational pause has been thoroughly studied, comparatively less is known about the characteristics of interfixational eye-movements.

Incidental information from the investigations of Erdmann and Dodge (1) and Shen (2) revealed that the proportion of the reading time taken by eye-movements fluctuated between 5 3 and 8.1 per cent, with the majority of the determinations clustered close to six per cent In a preliminary study, Tinker (3) found that 2 8 to 7.6 per cent of reading time was devoted to eye-movements. The average was 5.9 per cent From an analysis of his own results and those presented by Erdmann and Dodge, Tinker pointed out that the proportion of reading time taken by the moves was apparently determined in part by the reading attitude. With rapid, straightforward reading of easy material a larger percentage of time was taken by moves than in careful and analytical reading In a more recent study Walker (4) reports that on the average 10 per cent of the reading time was taken by the moves in each of the three selections which varied in difficulty[2]

Walker's findings are out of line with previous findings in two respects. (1) His movement-time duration of 10 per cent is the largest ever reported (2) He failed to obtain a change in the percentage of time taken by eye-movements when the difficulty of the reading material was changed, as did both Erdmann and Dodge, and Tinker

To check previous findings and to obtain a more comprehensive picture of the changes in eye-movement time produced by variation in reading material, a new experiment was performed to determine the variation in eye-movement time with (1) variation in printing arrangement of material used, (2) variation in difficulty of the material read; and (3) variation in type of reading response which consisted of oral reading, silent reading, and single-word response on multiple-choice test material

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[1] The expenses of this study were met by a research grant from the Graduate School, University of Minnesota

[2] There is a typographical error in Walker's Table 3, p. 103 Citation of Tinker's data for formulas should be 97 2 and 2.8 rather than 90 and 10 per cent of time taken by perception and by moves respectively

Ten university students with normal vision served as subjects in the experiment. Eye-movements were photographed while nine different selections of approximately ten lines each were read. Comprehension of the reading was checked. Each subject was adapted to the experimental situation by practice trials. Text read on the practice trials furnished context for the materials read in the experimental series. The reading selections, all printed in 10-point type with 2-point leading on eggshell paper, are listed below.

Selection B, very easy prose (fourth-grade level), 25-pica line width, silent reading.

Selection X, very easy prose, 25-pica line width, oral reading.

Selection C, easy narrative prose (from Stevenson's "Kidnapped"), 9-pica line width, silent reading.

Selection D, easy narrative prose, 19-pica line width, silent reading.

Selection E, easy narrative prose, 40-pica line width, silent reading.

Selection F, hard scientific prose (comparative psychology literature), 25-pica line width, silent reading.

Selection G, Algebra problem including formulas, 20-pica line width, silent reading.

Selection H, Chapman-Cook Speed of Reading Test, 19-pica line width, silent reading with a single-word oral response on each section to show comprehension.

Selection I, five multiple-choice examination questions on general information, 25-pica line width, silent reading with a single-word oral response in giving the answer.

This material has a wide range of difficulty and includes several types of reading material printed in a variety of arrangements. It is obvious that several methods of response were required from the readers.

The photographic records were enlarged with a projection lantern and carefully read for pause duration and movement duration. Re-reading part of the records revealed a very high degree of constancy in the reading. The unit of time used was one-fiftieth second. Combined results for nine types of material and for the ten subjects follow:

Average movement time per selection = 71.9, A.D. = 4.6

Average pause or perception time per selection = 961.6, A.D. = 111.4

Percentage of time devoted to moves = 7.3

Percentage of time devoted to pauses = 92.7.

Ratio of movement time to pause time = $\frac{1}{12.7}$

These data are quite comparable to those cited by Tinker (3). Individual differences were rather marked in both movement times (64.2 to 79.3) and pause times (688.0 to 1162.4) although they were relatively much greater for the pause times. This indicates relatively greater stability for the movement times, a trend which is also revealed by the average deviations cited above.

The data for movement time and pause or perception time for each kind of material and the ratio between the two are given in Table 1. The percentage of time taken by the moves varied from 5.3 for the reading of an algebra problem (*G*) to 9.6 for reading very simple prose (*B*). This means that from (approximately) one-nineteenth to one-tenth of the reading time was devoted to eye-movements. The smaller percentages of movement time seem to occur with reading the more difficult material (*F* and *G*), with oral reading (*X*), with narrative in very short lines (*C*), and with objective questions (*I*). In contrast, the larger percentages appeared when easy prose in medium or long lines was read silently. The differences in percentages for movement time, however, are probably not significant, with the exception of the extreme values. That is, movement time for the silent reading of easy prose is proportionately greater than for the reading of difficult material (9.6 vs. 5.3 per cent). Apparently analytical reading, as for selections *G* and *I*, requires more and longer pauses and consequently a longer perception time than for reading easy narrative prose.

TABLE 1

AVERAGE PERCENTAGE OF READING TIME TAKEN BY MOVES AND BY PAUSES AND AVERAGE RATIO OF MOVEMENT TIME TO PAUSE TIME

Measures compared	Kinds of reading material *B*	*X*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
I. Move, time %	9.6	6.2	6.4	8.1	8.5	7.3	5.3	7.9	6.2
II. Pause, time %	90.5	93.8	93.6	91.9	91.5	92.7	94.7	92.1	93.8
Ratio* I:II	$\frac{1}{9.8}$	$\frac{1}{15.7}$	$\frac{1}{15.1}$	$\frac{1}{11.6}$	$\frac{1}{11.1}$	$\frac{1}{13.2}$	$\frac{1}{18.8}$	$\frac{1}{11.9}$	$\frac{1}{15.6}$

*Each ratio is a group average of ratios, not $\frac{9.6}{90.5}$, etc.

Our 9.6 per cent for movement time in reading very easy material corresponds closely to the 10 per cent found by Walker (4). His failure to find variation in percentage of movement time with change in difficulty of the textual material was possibly due to the fact that he employed only highly efficient readers. Probably all material was fairly easy reading for them. In general the findings of this study confirm those previously cited by Tinker (3).

CONCLUSION

For all materials, less than 10 per cent of the reading time was taken by eye-movements. The range was 5.3 to 9.6 per cent (about one-nineteenth to one-tenth) with an average of 7.3 (about one-thirteenth) per cent. This allowed about 93 per cent for the pauses or perception time. In general, the more careful and analytical the reading, the smaller the relative time taken by moves. Apparently in the more complex types of reading, in which the mental processes of apprehension and assimilation become involved, less time is devoted to movements and more to pauses which are the periods of perception. In oral reading and in reading very short lines of narrative there was also a tendency to devote relatively more time to pauses. The findings in this study are in close agreement with previous results.

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BASAL METABOLISM AND MAZE LEARNING IN RATS

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I. INTRODUCTION

The present paper is in the nature of a preliminary report of a program of experimentation which we hope to pursue in the animal psychology laboratory of the University of Minnesota during succeeding years. This program is based upon the assumption that behavior can be understood fundamentally only in the light of our knowledge concerning the biological factors underlying that behavior.

It is admitted that an interesting and, for many purposes, a valuable system of behavior may be built without the systematizer's having recourse to other than psychological terms and concepts. We believe, however, that systems of this kind must and will give way as knowledge of the biological mechanism underlying behavior increases

The particular behavior under consideration at the moment is that of maze learning in rats However, instead of using the more usual technique of running a group of animals and then correlating their maze records with some physiological, neurological, biochemical, or histological measurement, we have determined to develop two lines of animals by a process of selective breeding similar to that used by Tryon (6) with reference to maze learning and likewise similar to that already used by Rundquist (5) on, so-called, spontaneous activity The advantage of this rather laborious method is that, if it is successful, one will eventually be dealing with two homogeneous groups—one at either end of the distribution It may be possible also to extend the range of the total distribution beyond that which is secured with a random sampling of a heterogeneous population The net outcome should be that the results of comparing two such groups with reference to some other characteristic will be less liable to be rendered ambiguous through the influence of errors of measurements.

II. Apparatus and Methods

The maze used is the automatic one described by Heron (2) The pattern which is used is, in terms of the successive correct turns to be made by the animal, as follows: LRLLRRLRLRRL The animals were given preliminary training in order to accustom them to the maze situation. They were run 27 trials on the maze but only the errors on the last 25 are used because the first two trials are so largely a matter of chance

The method which we used for the determination of the basal metabolic rate is essentially the same as that devised by Ebeling and Corey (1) for mice This method is fully described in the article to which we refer However, we should point out that: (1) We increased the size of the chamber in which the animal is placed in order to take care of the difference in size of the rat as compared with the mouse (2) We did not use an anaesthetic since we found that the rats would remain fairly quiet without it. In fact, many of them went to sleep during the test Under these circumstances, we decided that we would omit the anaesthetic as it is difficult to give in such amounts as to be sure that it does not affect the rate of respiration and thereby change the basal metabolic calculations. (3) We did not use a constant temperature water bath The temperature of the room in which the records were taken remained constant within a few degrees and, since a temperature correction is made in the calculation of the respiratory quotient which in turn enters into the calculation of the basal metabolic rate, it did not seem essential to use the water bath.

III Results

The data presented in Table 1 are from the F2 generation of animals. This means, of course, that the two groups of good and poor maze learners are not yet well separated. If one inspects the differences for errors, one finds that in group one there is a significant difference between the bright and dull animals ("Bright" indicates those animals the parents of which were relatively good maze learners, and "dull" indicates those whose parents were relatively poor maze learners. No other significance is implied in the use of these two terms.) However, in group two there is not a significant difference. The difference between groups one and two is that group two was started in the maze after group one had been running in it for one week. The reason for this was that it takes a number of hours for 50 animals to go through the maze during the first few trials. Therefore, it was thought wise to start one-half of the animals before the other half. The animals started first were the older animals and therefore all animals started the maze at approximately the same age.

TABLE 1

Comparison of Bright and Dull Animals in Respect to Average Errors in the Maze and Average Basal Metabolic Rate (Cal./gm./hr.)

Numbers in parentheses = number of cases

		Bright	Dull	*D*	σ_D
Group 1	Errors	94 (26)	128 (16)	34.	6.52
	B.M.R.	5.89	5.26	.63	357
Group 2	Errors	80 (24)	92 (35)	12.	5.59
	B.M.R.	7.27	6.36	91	313

A further inspection of the table will show that in basal metabolic rate the animals from good maze learning parents show a slightly higher rate than those from poor maze learning parents in both groups one and two.

IV Discussion

The data here presented are not to be interpreted as proving that basal metabolic rate is related to maze learning. This experiment is exploratory in nature only. However, the tendency of the data is such as to lead to the thought that, when the process of selective breeding has proceeded far enough to give a good separation of the bright and dull strains, then there may be found a definite difference in the basal metabolic rates of the two strains. This tentative conclusion is further indicated by the conjunctive results of two other studies. Rundquist and Bellis (4) found, in their study of the basal metabolic rates of active and inactive strains of animals, that the inactive strain have a lower rate than the active strain Rundquist and Heron (5) found that the inactive strain is poorer in maze learning ability than the active strain.

If this tentative conclusion is substantiated by further work then this question will arise What is the nature of the relation between these two characteristics? The answer to this question may hinge first upon the factor of motivation A higher metabolic rate means that fuel is being used more rapidly. Since the animals all receive the same amount of food, it may be that those with the higher metabolic rate are more highly motivated at each trial This hypothesis may be tested by using a device to measure motivation or by changing the motive and incentive from hunger and food respectively, to some other condition, e g, escape from water.

However, that is just one side of the problem; the other side may be stated in the form of this question' What is the physiological basis of the higher metabolic rate? Probably the most promising first line of attack upon this problem would be a study of the thyroid gland since the activity of this gland is known to influence the metabolic rate.

These suggestions are made to show how it may be possible ultimately to understand the nature of individual difference in maze learning ability in terms of physiological and neurological factors underlying that ability

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THE MOMENT OF STUTTERING*

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In reviewing available reports of research dealing with stuttering, observing clinical cases, and analyzing our own stuttering, we arrived at the conclusion that no available interpretation accounted adequately for all of the facts to be found in a study of the moment of stuttering. We therefore drew up an hypothesis to account for the phenomena related to the moment of stuttering, submitted this to the test of further and more intensive observation and analysis (such observation and analysis being made in actual speech situations rather than in laboratory situations), revised it repeatedly, and finally formulated it as here presented. Our interpretation involves configurationism, which is defined as "the theory that psychical and physical function occurs through configurations acting as units or in interrelation" (4). Our interpretation should be regarded as tentative.

According to our interpretation, the moment of stuttering may be broken down into four fairly distinct configurations the neurological, the precipitative psychological, the reactive psychological, and the communicative

The speech disturbance which is called stuttering may then be defined as the manifestation of conflict between the communicative configuration and one or more of the other three configurations. We do not mean to imply that this conflict occurs characteristically on a conscious and voluntary level.

Figure 1 is a schematic analysis of the moment of stuttering as interpreted here. The neurological configuration includes a general factor which Travis (3) has termed a gradient of excitation with fluctuating stability subserving the speech function, and a group of special factors—transient physiological states—such as fatigue, physical injury and shock, toxic and nutritional conditions, and the physiological accompaniments of that emotion which is no way a reaction to stuttering. There is another special factor which has its genesis in the effects of the operation of the configurations opposed to the communicative configuration, this factor is to be identified as the physiological accompaniment of emotion which is a reaction to stuttering These special factors may operate to interfere with the maintenance of a degree of stability, in the above-mentioned gradient, sufficient to prevent neuromuscular incoordination in the operation of the speech mechanism.

The precipitative psychological configuration heads up dynamically in the impulse to inhibit expected stuttering, which is expressed overtly, as far as the objective description of it is concerned, as a partial inhibition of speech This impulse to inhibit is aroused by the definite expectation of stuttering.

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*This paper is a part of the publications resulting from the University of Iowa Program of research on stuttering directed by Professor Lee Edward Travis

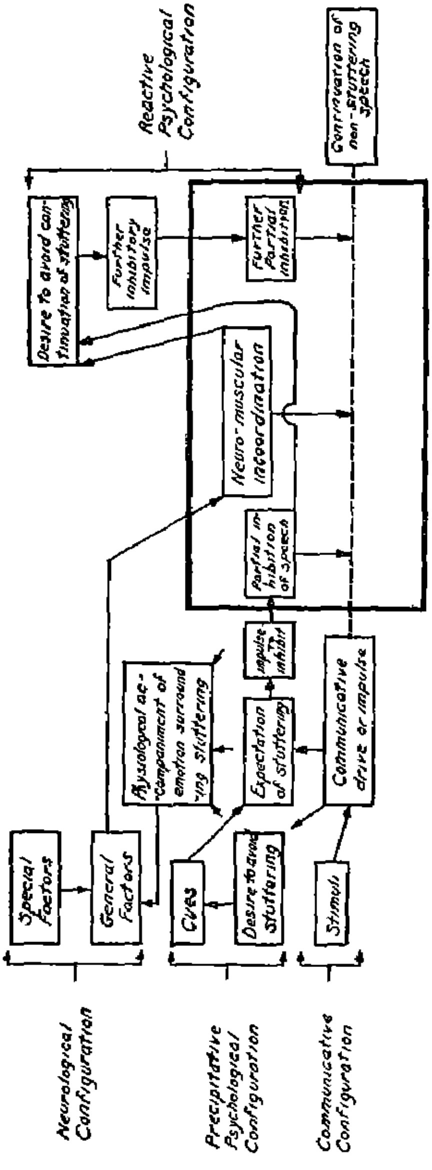
Neurological Configuration
Special Factors
General Factors
Precipitative Psychological Configuration
Cues
Desire to avoid stuttering
Communicative Configuration
Stimuli
Physiological ac-companiment of emotion surrounding stuttering
Expectation of stuttering
Communicative drive or impulse
impulse to inhibit
Partial inhibition of speech
Neuro-muscular incoordination
Further Partial inhibition
Desire to avoid continuation of stuttering
Further inhibitory impulse
Reactive Psychological Configuration
Continuation of non-stuttering speech

Fig 1 The Moment of Stuttering and Conditions Surrounding It

This in turn is precipitated by various psychic and organic cues to which the stutterer is made more and less sensitive by variations in the strength of the desire to avoid stuttering.

Insofar as this configuration is related to a particular spasm it is *precipitative* in nature, but it must also be recalled that insofar as this particular spasm stands in relationship to past spasms, this configuration is *reactive* in nature. However, since we are here dealing only with the moment of stuttering, we have treated it in the former sense

The reactive psychological configuration heads up dynamically in the impulse to inhibit the continuation of stuttering, which impulse is overtly expressed, again as far as the objective description of it is concerned, in a furtherance of partial inhibition of speech. This reactive inhibitory impulse is activated by a desire to avoid the continuation of stuttering which is actually being experienced during this moment of stuttering.

The communicative configuration may be described as the impulse to communicate orally, and the execution of that impulse, together with the stimuli arousing it These stimuli appear dynamically in the social milieu in which the stutterer finds himself The communicative impulse which they arouse may activate the desire to avoid stuttering and the expectation of stuttering. The conflict between the communicative configuration and the other three configurations takes place at points 1, 2, and 3 as shown in Figure 1

In the boxed area in Figure 1 are represented the types of disturbance which are recognized as stuttering. During any given moment of stuttering all three types of disturbance, or any two of them, or any one alone may be present, with the exception that the inhibition involved in the reaction to the given moment of stuttering very probably does not occur in the absence of one or both of the other two types of disturbance

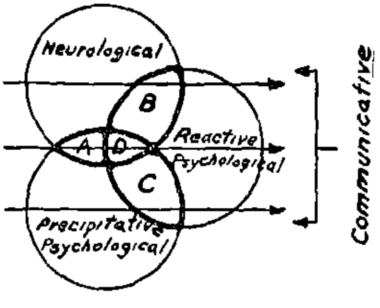

Fig 2 The Configurational Conflict in the Moment of Stuttering

Figure 2 shows more clearly the inter-configurational conflict during the moment of stuttering. Area *A* represents the communicative configuration versus the precipitative psychological and the neurological configurations. The resultant conflict is manifested in partial inhibition of speech, precipitated by the impulse to avoid expected stuttering, and in neuromuscular incoordination. Area *B* represents the communicative configuration versus the neurological and the reactive psychological configurations. The conflict here is manifested in neuromuscular incoordination and in partial inhibition of speech, arising out of the impulse to inhibit the continuation of stuttering Area *C* represents the communicative configuration versus the precipitative and reactive psychological configurations This conflict is manifested in partial inhibition of speech precipitated by the impulse to inhibit expected stuttering, and in further partial inhibition of speech arising out of the impulse to inhibit the continuation of stuttering. It is to be noted that the speech disturbance represented in this area does not involve neuromuscular incoordination Area *D* represents the conflict between the communicative configuration and the other three It is manifested in all three of the types of disturbance which have been described.

The therapeutic implication is that the configurations opposed to the communicative configuration must not merely be controlled through superficial alteration but must be reduced to the point of ineffectiveness

This interpretation includes what we regard to be acceptable in previous interpretations of stuttering, and it differs from them in various respects In the first place, it is to be understood that this paper deals with *the moment of stuttering,* rather than with stuttering as a long-term condition. It indicates the extent to which the theories of Travis (3), Bluemel (1), and Fletcher (2), in particular, account, each in its own way, for the phenomena involved in the moment of stuttering, and it also indicates the manner in which these various theories may be related.

In preparing this paper we have intended only the presentation of essentials, and, therefore, we have purposely avoided the elaborations which are obviously indicated We have meant to set forth a framework for further and more intensive investigation of stuttering, and also an interpretation in terms of which a broader and generally more adequate understanding of stuttering might be immediately possible.

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THE FACTOR OF ATTENTION IN RELATION TO THE MOMENT OF STUTTERING*

JOHN R KNOTT AND WENDELL JOHNSON

In a previous article (1) we have interpreted the moment of stuttering as involving one neurological and three psychological configurations, dynamic in nature, which act upon the stutterer In brief, speech, the product of the communicative configuration, is interfered with by·

a. A precipitative inhibitory configuration, which may be described as the impulse to inhibit expected stuttering.

b A neurological configuration, acting through insufficient hemispherical dominance of the speech gradient, as explained by Travis (2).

c A reactive inhibitory configuration, which may be described as the impulse to inhibit the continuation of stuttering.

As a corollary to this we now wish to propose that the precipitative inhibitory impulse which provokes the moment of stuttering is brought about through the function of attention and, in the proper sequence, that the reactive inhibitory impulse is provoked also by the function of attention.

A qualitative analysis of the moment of stuttering from this point of view may be sketched as follows.

Given a communicative situation, and given a strong desire or drive on the part of the stutterer to speak without stuttering (i e, to *inhibit* stuttering), then the stutterer will have a strong tendency, as he participates in that situation, to attend to the following

a potential stuttering (to be avoided) and

b. actually experienced stuttering (to be avoided or minimized).

Whenever, in attending to potential stuttering, toward which the stutterer expresses avoidance reactions, the total speech behavior tends to be inhibited This attentional set heightens the stutterer's sensitivity to such cues as may lead him to believe that the moment of stuttering is at hand,

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*This paper is a part of the publications resulting from the University of Iowa Program of research on stuttering directed by Professor Lee Edward Travis and in so doing it is instrumental in calling out the actual inhibition of speech (stuttering). This is possibly analogous to the attentional set utilized in reaction-time experiments involving the so-called muscular response, in which the attention is directed to the preparation to respond in a definite manner, any cue or signal being sufficient to set off the subsequent expected behavior.

Once the spasm has occurred, as precipitated by either the neurological or the psychological configuration, the reactive inhibition takes place, and with this is found the attentional set to (*b*) Herein the attention may be so great that the concommitant motor adjustment may be responsible for certain of the characteristic symptoms of the stuttering spasm, such as the marked disruption, through inhibition, of processes essential to the progression of normal oral communication.

From this discussion it is possible to set up a general law of the behavior of the stutterer in a communicative situation

The stronger the attentional set to stuttering, either potential or present, the more inhibited will be the speech behavior of the stutterer in that situation, this rule being valid in proportion to the degree that the attentional set provokes avoidance reactions on the part of the stutterer

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A STUDY OF THE OVERT ATTENTION OF YOUNG CHILDREN DURING CLINICAL EXAMINATIONS

ESTHER K. HARRIS

The purpose of this study[1] was twofold. (1) to determine whether a quantitative method of recording shifts in attention during a routine clinical developmental examination was practicable, (2) to study individual variations in overt attention shifts in an effort to determine whether personality factors are of primary importance or whether certain modes of attention are characteristically found in children of similar age or of similar intellectual status. By overt attention is meant apparent direction of the interest of an individual.

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[1] The study was made at the Clinic of Child Development, Yale University, under the direction of Dr. Ruth W Washburn

The records were taken during routine clinical developmental examinations so that the situation was relatively well controlled Only one child at a time was present. The observer was seated behind a one-way-vision screen near enough to see the child clearly and to hear all that was said but herself unseen The child was seated at a table about ten feet from and facing the observer. The timing device used in making the records consisted of a Becker time-marker mounted like an earphone, which ticked in the observer's ear every second. A check for each second could be made on a paper fastened on a clipboard without the removal of the observer's eyes from the subject[2] A time-sampling method with five-minute intervals was employed. An average of three records was made of the behavior of the child

The purpose of the observer was to give a picture of the child's behavior with respect to attention as defined above throughout the time he was in the examination room For this reason symbols for attention or non-attention alone were not sufficient; it was necessary to show what form the attentive or non-attentive behavior took This meant a set of

TABLE 1

SYMBOLS FOR RECORDING ATTENTION

F	Free use of materials presented without instructions
A	Watching while test materials are presented or put away
A—	Attempting to perform according to suggestion of examiner or using the materials in the right way without instructions
Az	Staring at examiner or materials after they are presented instead of performing according to suggestion.
Ax	Refusing to perform, shaking head, pushing materials away, etc
Ap	Play use of test materials, pushing, throwing, banging
P	Playing with objects other than test materials
O	Observing, looking about room
W	Wriggling, playing with hands, etc
G	Gross motor activity, excursions about room.
C	Crying.
V	Vocalization, conversational jargon
T	Talking, words or sentences not part of the examination.
L	Laughing, smiling
(	Glance at mother
)	Glance at examiner

These last five symbols were rarely used alone, but were inserted to express accompanying behavior They were not figured as percentages The number of times the child talked or laughed was recorded symbols adequate to cover as many types of behavior as possible pertinent to the problem. By the trial-and-error and approximation method the symbols above were worked out and proved satisfactory.

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[2] For a more complete desciiption of this device see Washburn (1)

The observer found it possible to check pertinent behavior occurring in the examination room using these symbols. Table 2 shows a record of the behavior of Case 3

TABLE 2

Sample Five-Minute Record

Case 3	21 mos.	304 checks
A—	ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ	
	L T	
G	ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ (ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ	
	T	
A—	ǀ ǀ	
	T T	
G	ǀ ǀ	
	L	
A—	ǀ ǀ	
G	ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ ǀ	
	T T T	
Ax	ǀ ǀ	
Ap	ǀ ǀ ǀ ǀ	
	T	
G	ǀ ǀ	
	L T	
F	ǀ ǀ	

The number of checks for each symbol was counted and the percentage of the total for the five-minute observation determined. When the results of all the observations for that child were totaled, one had a picture of his behavior during the examination Table 3 summarizes the above record.

TABLE 3

Case 3	21 mos	1 record
43%	Attending to the test situation	
	12% Free play with materials given for the purpose	
	31% Attempting to perform	
2%	Play use of test materials	
9%	Staring at examiner or materials instead of attempting to perform	
46%	Moving about the room	
	Looked at mother	1 time
	Made voluntary remarks	9 times
	Laughed	3 times
	Number of attention shifts	10 times

In order to check the reliability of these records, all the descriptive comment on the clinical examination record and the clinical examiner's descriptive account of the whole period were studied and compared with the observer's records If the attention record on the average gave a picture corresponding to the clinical record it was checked + If it showed all the marked characteristics mentioned in the other accounts of the same period it was checked ++ Fifty per cent of the cases were +, and 43 per cent were ++. As the description was sometimes very meager, and as there is always a possibility in the time-sampling method that a given type of behavior may occur during a non-recorded interval without repetition later, this was felt to be a very satisfactory agreement.

The group used for study was a heterogeneous one. Records were made of 29 subjects, 15 boys and 14 girls. The age range of these subjects was from 13 to 61 months, with a fairly even distribution.

The classifications obtained from the clinical records ranged from defective to superior with the largest number of subjects falling in the average group. Although the number of cases was not large, it represented a sampling of children examined by the clinical service—17 dependent, 6 with mental or physical defect, 3 behavior difficulties, 3 follow-up studies. A method of recording overt attention in a test situation which has proved so satisfactory for such a group is presumptively applicable to more general use

For purposes of comparison the records were chronologically arranged in age groups of six-month intervals Graphs were made of those attention categories which occurred most often, viz, the total percentage of attention to the test objects, of gross motor activity, of refusal to perform, and of play use of material. The *attention total* showed more variation and was lower at 18-36 months than at any other time. At 18-24 months this decreased attention was accompanied by a marked increase in motor activity. This can be partly explained by the fact that the younger child is unable to leave, unaided, the chair at the small table where the examination is conducted When he acquires this ability he practices it to the detriment of his attention score. *Refusal to perform* was low at all levels with marked variation on a few records *Play use of materials* reached its highest level during the 18-24 months' period and showed a slight decrease in the upper age levels. The amount of talking or vocalizing and the number of attention shifts were also studied but showed no special age differentiation

A rearrangement of the records according to the reason of reference of the child to the clinic resulted in three groups—dependent children, children with physical or mental defects, and children who were brought in for guidance or checkup examinations Certain tendencies were characteristic of these different groups The *motor activity* was practically the same for all of them. *Refusal to perform* appeared most consistently in the dependent group. This group also exhibited a greater amount of *passive resistance,* staring at the examiner or materials instead of performing as instructed *Play use of materials* was most prominent in the group of defective children. The guidance group was characterized by *greater freedom of speech*

The behavior pictures presented by these records are, then, gratifyingly accurate The picture shown by Case 3, of the two-year-old, bent on exploration of his environment, is at once recognized as a true one by those familiar with children of this age. Moreover, that the dependent children were more negative, the children with behavior questions more freely talkative, the defective children more rigidly persistent in playing unadaptively with the test materials—was corroborated by comparison with the clinical records Though the findings apply only to this particular group, the fact that there was correspondence between these and other findings in the study of the same children is an added reason to indicate that this quantitative method may be an aid to further study of the phenomena of attention in clinical situations

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ANOTHER "INSIGHT" EXPERIMENT

FRED S KELLER AND LYNDON M HILL, JR.

In 1930 Tolman and Honzik (2) reported three experimental studies dealing with the problem of "insight" in rats Following the general technique of Hsaio's (1) earlier work, these investigators sought to determine whether rats were capable of grasping "a material, inner relation of two things to each other." More specifically, their aim was "to discover whether a rat can get the 'insight' that two paths have a common section—that, if the common section is closed, both of these paths are useless and that only a third, alternative path not including the common section remains as the proper one whereby to reach the goal."

Although the first of the Tolman-Honzik experiments utilized a tunnel maze similar to the one with which Hsaio secured evidence of "insight" in the three rats of his experiment, the results were negative This was also the case in the second experiment when a tunnel maze, similar in principle but of different design, was used In the third experiment, however, with an elevated maze of the same pattern as that of Experiment II, positive results were obtained with nearly all of the animals used

Failure to confirm Hsaio's results in the first of their experiments is considered by Tolman and Honzik as possibly due to (*a*) the slightly altered shape of their maze or (*b*) the difference in amount and distribution of training preliminary to the "insight" tests. The contradictory results of their own second and third experiments are attributed to the nature of the maze used in the latter. Since this maze had no sidewalls it enabled the rats "to 'see' the situation as a whole" or at least "may have served to accentuate the relations between the paths"

The experiment reported herein was of the same general nature as the third Tolman-Honzik study. (For a detailed account of the latter the reader is referred to their paper.) The seven white rats used were females and litter-mates of Wistar stock, five months old at the beginning of training

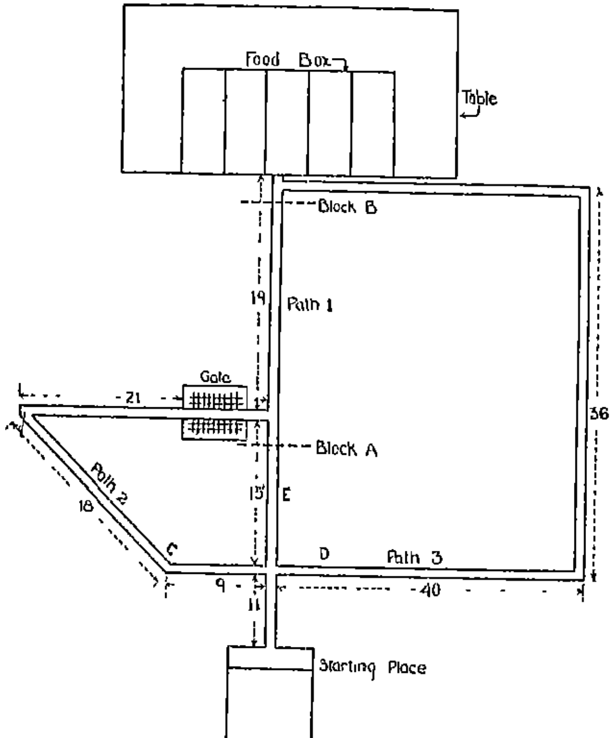

FIGURE 1
MAZE USED IN TOLMAN-HONZIK "INSIGHT" EXPERIMENT

For one week prior to the experiment proper they were placed upon a three-hour-a-day feeding rhythm, with a diet consisting of commercial dog biscuit supplemented occasionally by fresh vegetables. The apparatus employed was a reproduction of the Tolman-Honzik maze (Figure 1), except for two details of construction (*a*) there was a slight difference in the nature of the food box—a single, partially enclosed platform serving in the present experiment; and (b) the "Gate" on path 2 was eliminated, blocking being done by means of cardboard blocks (18 in high x 13 in wide) which fitted snugly over the maze paths. Further mention of this change in blocking will be made later

For the first seven days of the experiment each rat was given six runs a day, with freedom to choose either of the three pathways. (The usual three-hour feeding followed the runs.) Table 1 presents the choices for each animal, together with the number of times no pathway was chosen within a five-minute period. It may be seen that all of the animals showed a decided preference for path 1, at least eight of the last ten runs of this series for each rat were over this route to food.

TABLE 1

Path	Rat 1	2	3	4	5	6	7	Total
1	21	13	30	39	36	28	22	189
2	7	7	2	0	4	4	2	26
3	5	8	1	0	0	6	12	32
None	9	14	9	3	2	4	6	47

Immediately following these runs each rat was given six runs daily, in all but one of which the cardboard block was present in the first segment of path 1 (*A* in Figure 1), leaving paths 2 and 3 alone accessible (The exceptional run, with all paths open, was selected at random from the day's trials.) This procedure was followed for seven days, with the results shown in Table 2 In more than 90 per cent of the runs each animal went down path 1 to *A* and returned to the main intersection to choose paths 2 or 3

On the fifteenth day of the experiment the "insight" tests were given

TABLE 2

Path	Rat 1	2	3	4	5	6	7	Total
1	7	4	5	2	7	3	6	34
2	29	28	31	39	16	31	23	197
3	6	9	6	1	19	8	13	62
None	0	1	0	0	0	0	0	1

With the block placed in the common segments of paths 1 and 2 (*B* in Figure 1) the rats were released as usual and their behavior was carefully observed. Because of the importance of this behavior in the discussion that follows, the conduct of rat 1, which was typical, is recorded in detail below.

Rat 1· ran to *B*, back to the *nearest* intersection of paths 1 and 2; out on path 2 about nine inches, paused, stood on hind legs facing and reaching in the food-box direction, then continued slowly down path 2 in the direction of the entrance. Halfway to the entrance she was removed and placed at the starting-point once more Again she went to *B*, and again out on path 2 for a short distance, and then turned around to retrace path 1 slowly to the main intersection where she chose path 3 to food.

Similar behavior was observed in all the other animals. Each rat, upon entrance into the maze, went to *B* and then turned into path 2 at the nearest intersection. Two animals (4 and 6) acted in a manner almost identical to that of rat 1. Three of them (2, 3, and 5) behaved differently only in that they did not attempt to return over path 2 to the entrance. Instead, after finding the block at *B*, they entered path 2 for a short distance, paused (as had rat 1), and then slowly retraced path 1 to the main intersection where they too chose path 3 Rat 7 alone took path 2 after performing in the fashion of rats 2, 3, and 5 up to that point.

This test was repeated three times On the second run the behavior of the rats was almost identical with that of the first, on the third and fourth all of the animals, after being blocked at *B*, merely paused at the nearest intersection, looked in the direction of path 2, continued retracing 1, and chose 3 to food

Immediately after these tests a second phase of the experiment was carried out with the same subjects and technique, but with a slight change in apparatus. The third segment of path 2 (the one first entered in the return trip from *B*) was hinged at its outer end and joined to path 1 in a manner that permitted it to be quietly disconnected from the latter when the experimenter pulled a cord attached to the path and running through a pulley above the maze

For seven days more the rats were given training similar to that which had preceded the "insight" tests, but with a slightly greater number of runs permitted each animal over path 1 in order to make sure of re-establishing the usual preference Table 3 gives the number of times each rat traversed each path to food (The number of runs in which there was no block at *A* is indicated roughly by the path-1 record in the table)

With the second "insight" test the following procedure was adopted When the animal reached block B, path 2 was drawn out of its usual position snug with path 1 and but one route was left whereby she could return to the main intersection. The results obtained were unequivocal. Each

TABLE 3

Path	Rat 1	2	3	4	5	6	7	Total
1	9	8	10	5	11	11	8	62
2	23	22	18	27	26	26	27	169
3	10	12	14	10	5	5	7	63

rat went to block B as in the previous test None appeared to be disturbed by the removal of path 2 while at the block All of them paused at the point where path 2 had been disconnected and all retraced to the main intersection where, with one exception, they chose *path 2*. The exception was rat 3 who had previously shown no significant preference of path 2 over 3 On a second test in the same experimental period five of the seven animals chose path 3, on a third only three were "successful"

In order to be certain that the amount of training in this experiment was equal to that of the Tolman-Honzik experiment an additional series of 42 training runs and five "insight" runs was given each animal. The technique was unaltered except for the use of a glass block instead of the cardboard one of the earlier trials The results were essentially the same as those already presented and need not be recorded here in detail. One rat only chose path 3 consistently; three others chose it once or twice; and the remainder showed a strong preference for path 2

With respect to the interpretation of these results we may consider the following In the first part of this experiment, when the "insight" test was given, six of our seven subjects chose path 3 upon return to the choice point after blocking at *B* In terms of this choice alone the results obtained by Tolman and Honzik were similar, and one might conclude that "insight" (in the Tolman-Honzik sense) was operative In so doing, however, a very significant aspect of the animals' behavior would be neglected: namely, their entrance for some distance into the third segment of path 2 after having been blocked at *B*. This behavior, as well as the pause of each animal at a place a few inches along path 2, points to a simpler explanation.

The same block was used at positions *A* and *B*, and the relationship between the block at *A* and the first segment of path 2 was similar to that between the block at *B* and the third segment of this path During the training period the animals had learned to take path 2 after the blocking at *A*, in the "insight" trial (block at *B*) they *failed to discriminate* between the two situations. This hypothesis is supported not only by their immediate entrance into the third segment of path 2 after *B*-blocking but also by their prolonged pause in this pathway at a point approximately the same distance from path 1 as that of the *first turn* from the main intersection (The subsequently attempted complete return over path 2 after *B*-blocking, when it occurred at all, was always extremely hesitant and slow.)

Ample confirmation of this was given in the second phase of our experiment where, after blocking at *B*, and in spite of previous training on the "insight" solution, all but one of the rats chose path 2, the third segment of which was temporarily disconnected from the final one common to paths 1 and 2. The most obvious characteristic of this behavior is the lack of "insight" shown; in spite of the fact that every essential condition specified by Tolman and Honzik seems to have been provided

This does not, of course, explain the results of the Tolman-Honzik study (an exact duplication of which would be extremely difficult); but it does render suspect their conclusion for "insight" in any but a very limited sense and points once more to the pitfalls of interpretation so characteristic of this type of experimental research.

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INVERSE WRITING. A CASE OF CONSISTENT MIRROR WRITING[1]

Norma V. Scheidemann

The Case. When Thomas M, a six-year-old Mexican boy, entered the first grade he presented a phenomenal tendency to copy, at his desk, all blackboard material in inverse position. Drawings of men, houses, automobiles, trees, ice cream cones, and the like, were copied carefully but in inverse position For experimental purposes many outline drawings, some in inverse position, were made on the blackboard and Thomas was asked to reproduce them In each instance the child reproduced the drawing carefully but inversely, so that the pictures that were presented in an upside-down position by the experimenter were reproduced right-side-up by the child When drawings were presented at the child's desk, that is in the horizontal plane, they were reproduced not in an inverse position, but in the reverse position of the so-called mirror writing This procedure was followed systematically with pictures and also with meaningless designs that could not have been associated with faulty habits When asked to draw a picture without a copy before him, Thomas drew it in inverse position

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[1] The child reported in this article was enrolled in the Transition First Grade of the Hammel Street School, Los Angeles, California, during the school year 1931-32.

The writer is indebted to Mr C. G Hopkins, principal, and to Gertrude Mount, teacher, of the Hammel Street School for helpful cooperation.

The same tendency was manifested when Thomas learned to write the digits and when he learned to write letters and simple words from blackboard copies The accompanying Figure I illustrates Thomas's typical attempts to reproduce pictures and numbers from the blackboard. Figure 2 illustrates early attempts to write "me" from a blackboard copy, Figure 3 is a copy of "me" written on Thomas's paper.

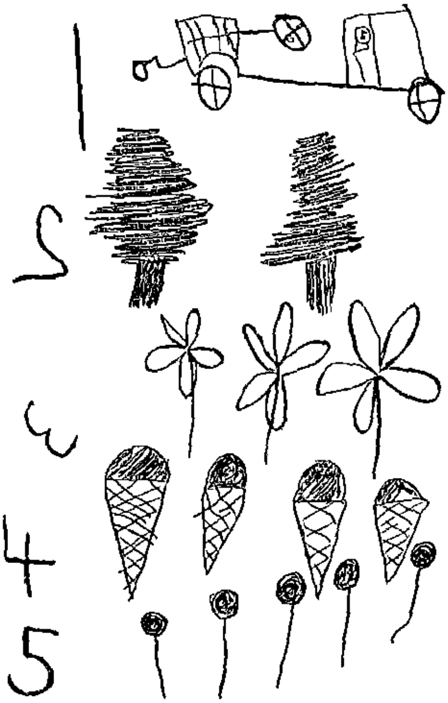

FIGURE 1

Drawings of a consistent mirror writer These pictures and numbers, copied from the blackboard, represent (1) car, (2) trees, (3) flowers, (4) ice cream cones, and (5) lollypops

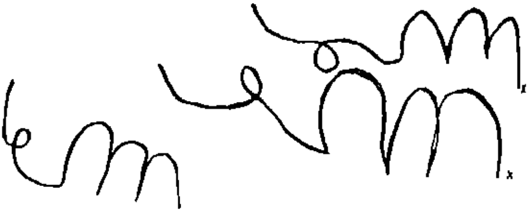

FIGURE 2
A consistent mirror writer's attempts to reproduce "me" from a copy on the blackboard.

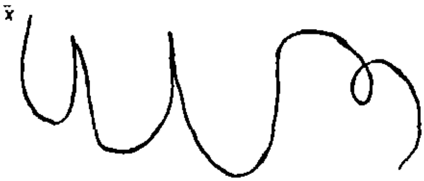

FIGURE 3
A consistent mirror writer's attempts to reproduce "me" from a copy on his desk. This was written a few minutes after the writing shown in Figure 2.

When counting a linear series Thomas always began at the right and counted toward the left Drawing and writing usually was begun at the lower right-hand (occasionally lower left-hand) corner of the page and was continued toward the left and upward

It is needless to say that unwarranted attention was not called to this peculiarity. The child's modest demeanor and eagerness to cooperate with the teacher precluded any conscious attempt to attract attention, he was naive in his performance.

History Thomas was a six-year-old blond Mexican boy of normal intelligence He was a pleasant and cooperative child and presented no disciplinary problems in school No peculiarities in behavior were noticed Except for the tendency toward mirror writing, Thomas made satisfactory progress, that is, in learning to count, learning to form letters and numbers, and to recognize a few words, his progress was normal His vision according to Snellen test charts was normal

In Thomas's family there are two other children, both definitely blond, a brother ten years of age, and a sister eight years. The sister is in a slow class of her grade. The father deserted the family several years ago; nothing is known of him. The mother, a Mexican, is reported to be psychopathic but no reliable information in regard to the basis of this assumption was available. She was found to be a large, strong woman, but utterly helpless in providing for her family. The home is little more than a make-shift of boxes. The family is supported entirely by benevolent agencies Only Mexican is spoken in the home.

Thomas is right-eyed and shows no left-handed tendencies This is noteworthy since all cases of mirror writing thus far reported have been encountered with left-handed children, and only with extremely left-handed ones

Diagnosis Thomas's aberration was diagnosed as consistent mirror writing. Inversing copy when reproducing from the vertical to the horizontal plane is mirroring the copy just as objects along the edge of a body of water are mirrored inversely on the surface of the water. Logically Thomas could be expected to inverse when reproducing above or below copy presented in the horizontal plane Tests for this were not made until some time after remedial work had been instituted. During these tests the child did not show tendencies to inverse copy in the horizontal plane when reproducing them above or below the copy in the horizontal plane; he continued to reverse the copy This may have been due to the association of habits of reversing, not inversing, material presented at the desk Until remedial work was begun, all material at Thomas's desk was presented alongside his paper

Although Thomas's aberration was thought to be consistent mirror writing, two distinct problems, inversing and reversing, were involved and had to be considered separately when outlining remedial work. Since learning to write is difficult in itself, it seemed desirable to isolate one of Thomas's faulty habits and to correct it before trying to correct the second Initial attack could be directed at either of the two problems with, perhaps, equal degree of effectiveness, but individual work with little disturbance to the class could be done more readily with the problem of reverse writing.

On the basis of this diagnosis it was thought best to present all copy in the horizontal plane and to institute customary remedial work for correction of reverse writing Then when correct writing habits were established it was thought that they could be associated with copy in the vertical plane This suggested that all remedial work be directed toward establishing correct writing habits and associating those habits with copy in both the horizontal and vertical planes. This was all that could be done since the cause or reason for the mirror writing was not known. Undoubtedly there was a cause far more deep seated than mere faulty habits and associations It is possible that the basic cause is a neurotic character trait

Thomas is not left-handed nor is he left-eyed, but he does have sinistrad tendencies of hand and eye instead of the dextrad movements required in our reading and writing It was thought best, therefore, that the child be taught to read by the alphabet method rather than by the word method since he might learn to recognize words by sinistrad eye-movements and still make satisfactory progress until the compounding of words or the building up of longer sentences were undertaken The sinistrad movements would then give difficulty because the child would have formed the habit of attacking the ends of words rather than the beginnings It is thought, generally, that learning to build up words from letters tends to encourage dextrad reading habits

Remedial Procedure Systematic remedial procedure to correct Thomas's anomaly was not begun until the beginning of the fourth week of school At this time all copy was presented in the horizontal plane and customary procedure for correcting reverse writing was instituted The child's progress in overcoming reverse writing was more rapid than in the case of children whose mirror writing is associated with left-handedness Throughout this part of remedial procedure, Thomas was permitted to see blackboard copy and also to observe children reproducing copy on the blackboard, but his own reproductions were made only at his desk. By the end of the ninth week of school Thomas had correct writing and drawing habits fairly well established; only occasionally did he resort to habits of reversing Copy then was presented in the vertical plane. Thomas showed no difficulty in associating his established motor habits with copy in the vertical plane. His work was watched closely, but no tendencies to inverse copy were observed by the close of the first semester. Occasionally a number, especially a "2," was reversed, but the child would recognize his mistake and would correct it immediately After the first year in school Thomas manifested no more difficulty in regard to writing habits

Thomas was given some instruction in word building by the alphabet method This method could not be used exclusively, however, since the class was taught by the word method So very little work in reading is done in the first semester of the first grade that this phase of remedial procedure had to be continued in the second semester.

Prognosis In all probability Thomas's motor habits required for writing and drawing are sufficiently well established. Occasional lapses may be evidenced, but may be corrected easily In later scholastic subjects Thomas may present the problems manifested by the extremely left-handed mirror writer He may show some special reading disability, he may reverse short words, reverse some letters within a word, and interchange letters of similar form When dealing with two or more digit numbers, the child may show tendencies to reverse them In fact whenever a definite sequence is required, Thomas may be expected to encounter difficulty.

In addition to the difficulties common to the mirror writer, Thomas may show other problems. If a neurotic character trait should be the cause of Thomas's difficulty, a non-conformity in some social habit or custom may be expected. Such a lack of conformity may be evidenced only in non-consequential habits such as eating or dressing, but in some way or other, at some time or other, some non-conformity may give manifestation of an abnormal character trait.[2]

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DECEPTION TESTS WITH JUVENILE DELINQUENTS[1]

VERNE W. LYON

The detection of deception by means of recordable physiological manifestations had its early inception in the work of Benussi, Munsterberg, Burtt and Marston, all of whom reported varying degrees of success within admitted limitations.

These limitations may be attributed in part to the experimentally devised situations in which the subjects were requested to falsify their answers to questions of an inconsequential nature where the ultimate outcome, whether favorable or unfavorable had no effect whatsoever on their safety, honor, liberty, reputation, or integrity. In the majority of instances, then, the situation under which the test was given was not such as to occasion profound emotional disturbance.

In 1921, Larson developed the continuous relative blood pressure and respiration technique with controlled experimentation in actual criminal investigations where the results could be checked by the actual facts later ascertained. This technique, which has been previously reported, has been used by us and is again briefly summarized. A polygraphic apparatus is employed which is designed to secure a continuous recording of the circulatory and respiratory changes characterizing the emotional state attending deception. In all cases, permission to conduct the test is secured from the suspect and a guarantee given him that no legal action will be taken on the basis of the test alone. A preliminary record is taken without any questioning so that an average cross section of the initial state of the sub-

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[2] Thomas's teachers and principal are watching closely for abnormal habits in the child. In the course of a few years the case will be reported in terms of developments.

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[1] Read at the forty-third annual meeting of the American Psychological Association, Ann Arbor, Michigan, September 4-7, 1935.

ject is secured This is followed by a record during three indifferent questions, free from any complex situations, and so framed that the truth of the answers can be checked at once The critical questions then follow in order, uninterrupted by any indifferent stimuli All questions are phrased so that they can be answered by either "yes" or "no."

We have selected at random from our files 100 cases of suspected deception which had been examined by us for the Juvenile Court of Chicago These cases were referred with the expectation that court disposition in some instances might be facilitated as a result of the test

It must be remembered, however, that not every case in which there is an original denial of guilt is referred for examination When a boy is first apprehended and denies complicity in the crime with which he is charged or of which he is suspected, he is subjected to routine questioning by the police officers who arrest him, the probation officer who prepares the case for court presentation, the psychiatrist who attempts to evaluate all of the available data, and the judge before whom the case is tried. In the majority of instances, innocence or guilt may be definitely established in the process of this routine and the finding corroborated either by external factors or subsequent confessions. It is only in those cases, then, where all of these agencies have completed their investigations and it is felt that pertinent facts are being withheld by the boy, that a polygraphic examination is requested

The results of our investigations may be divided into three groups (see table) In the first group are the so-called "clear" records where there is no evidence of emotional reactivity associated with responses to critical questions These records are considered presumptive of innocence While we have been able to secure verifying information in but seven of the 20 cases that fall in this group, yet in each of the seven our presumptions were definitely substantiated by the establishments of the facts

TABLE 1

RESULTS OF 100 DECEPTION TEST RECORDS ON JUVENILE DELINQUENTS

				Disturbed records	
Court charge	Boys	Girls	Clear records	Did not confess	Confessed
Sex offences	14	15	7	14	10
Robbery, etc.	67	4	13	33	23
Percentages	81	19	20	47	33
Totals	100			100	

Average age 15 years
Average IQ 85

In group two are placed those cases in which disturbed records were secured in conjunction with the denial of guilt, but where we were unable objectively to determine the actual facts. It will be noted that 47 per cent of our cases fall in this group.

In group three are placed those cases in which disturbed records presumptive of deception were immediately followed by admission of guilt.

In no way were these juveniles intimidated by the examiner nor were the results of the polygraphic examination misrepresented to them Each record is carefully studied and comparisons of the tension and the emotional reactions are made between the control section, the responses to indifferent questions, and the responses to critical questions When specific disturbances are noted in responses to critical questions, the subject is asked to explain the possible reasons for these disturbances. In no instance is he told that he has lied or that his story is incorrect Yet in 33 per cent of the cases examined, admissions of deception directly followed this procedure.

If it may be assumed that in 20 per cent of the total cases examined our presumptions of innocence are correct, we then find that in 41 per cent of the instances where disturbed records were secured, our impressions of deception are corroborated by later confessions of guilt The importance of this information is apparent. Or, if we combine clear records and confessions, we have a total of 53 per cent of the cases examined where the reports to the court may be helpful in disposition In those cases in which disturbed records are secured without subsequent confessions, an interpretation is returned to the court with the stipulation that these evaluations should not be used as evidence.

In the final analysis, the question of inability to differentiate and interpret the psychological significance of physiological reactions must find its solution in deception test principles. It is essential to realize that this testing does not detect lies, but painful complexes which are intensified by focusing the suspect's attention on questions of truth or falsehood. It follows that even if the suspect does not answer, there may still be disturbances because a reaction is obtained when a stimulus touches upon a painful complex just as an underlying infection responds to the painful probe of the surgeon On the other hand, the fear of the innocent, anger, nervousness, recidivism, and the pathological heart are conditions which may be important factors in influencing errors of interpretation, and because of this, such records should not be introduced into a court of law, unless the interpretations of guilt have been verified by the objective establishment of the facts. It is important also to emphasize the necessity for the careful selection and extensive training of personnel if reliable results are to be obtained in this field Much of the unfavorable criticism which is associated with deception tests may be attributed to the unscientific principles of overenthusiastic, untrained operators who are incapable of dealing with a clinical subject, probably the most difficult of all clinical fields—the evaluation of human emotions The technique is not infallible and may never be accurate enough to warrant court room use, but as a means of interrogating suspects and selecting them accurately, it compares favorably with other police or legal methods of investigation. It is of particular value in preliminary investigations where it may help to eliminate innocent individuals and enable the investigators to concentrate more thoroughly on a suspected few The limitations of the procedure must be definitely recognized, but when these are kept in mind, and the tests are properly conducted, no harm will be done and much good may accrue from the use of physiological methods of testing deception

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BOOKS

W N KELLOGG AND L. A. KELLOGG *The Ape and the Child A Study of Environmental Influence upon Early Behavior* New York: McGraw-Hill, 1933 Pp xiv + 341

Inasmuch as two years and more have passed since the publication of this book, there would be little reason for discussing here its organization and style. Many psychologists doubtless have formed an impression of the nature of the book by direct inspection, and for those who have not had direct access, the contents have been well summarized by three previous reviews (by Florence Goodenough, *Psychol. Bull*, 1935, **32**, 172-174; by Charles Honzik, *Amer. J. Psychol.*, 1935, **47**, 533-534, and by Maurice Krout, *J Abn. & Soc Psychol.*, 1934, **29**, 247-249).

An examination of these reviews and of several other printed comments on the book convinces me, however, that there is still considerable need for criticism of this book from the standpoint of the merits of the piece of research which it represents; and it is to such a consideration that this review is devoted

In general, the criticism that seems to me to be warranted is that although this book is a respectable contribution, its value does not come through any relation to the problem which it sought to illuminate, nor indeed through relation to any general theoretical problem. The data stand as a body of isolated facts that call for supplementation before they can achieve true scientific value

Such an outcome is not what the Kelloggs intended They hoped to clarify considerably the problem of the relative contribution of nature and nurture to human development, and in the first and last chapters of the book the study is interpreted as having this significance Doubtless a number of psychologists will accept such an interpretation. A previous review concludes with the statement that this book " . should be required reading in all courses where the problem of heredity and environment is discussed."

To decide whether the book has significance for this problem, several points must be considered. In the first place, this study has disclosed no new capacity or new type of reaction in the chimpanzee All of the accomplishments of this chimpanzee, as well as many other reactions of a higher type, have previously been reported in other chimpanzees reared without the advantages of the "humanizing" influences which the Kelloggs feel so important In the second place, there is no basis for saying that this chimpanzee developed any behavior that could be called "distinguishingly human." All of the actions shown were relatively simple sensorimotor functions. The fact that an animal can learn, for example, to wear clothes, to play with human toys, or to respond to language, is hardly a contribution to our scientific knowledge. The nature-nurture controversy rages over other matters than these, for it is obvious from other data that, within the range of activities permitted by the anatomical structure of an animal, there is a wide range of adaptations possible Whether a child eats with chopsticks or spoon or fingers is obviously a cultural product; and it is no new feat for a chimpanzee or monkey to endure clothes Of all the habits developed by this chimpanzee, perhaps the one most nearly distinguishingly human is responding to language, but even this item is of little importance in view of the demonstration of this same capacity even in animals as low as the dog.

The sole basis, therefore, on which this study might claim to contribute to the nature-nurture problem lies in the question of the *rate* of development of the capacities of the ape. And on this question we are completely up in the air—we have no control data which would make an interpretation possible The Kelloggs seem to have rested on the assumption that, since the adult capacities of chimpanzees are lower than those of humans, this infant chimpanzee would normally have displayed a lower and slower development unless environmental influences were the major determinants of the abilities of an animal This assumption is, of course, about as shaky as any proposition could be In animals of briefer lifespan, considerable learning goes on at an age that greatly undercuts anything seen in either chimpanzees or humans, so that certainly there is no simple correlation between age and the normal rate of psychological development And furthermore, even though the schedule of physiological development of chimpanzees approximates that of man in a good many respects (and the Kelloggs might well have indicated more definitely how much of a difference there is in this respect), there is no reason for believing that nervous development bears a constant relation to other phases of bodily development in different species. Especially since the relative size of the brain differs from ape to man, the burden of proof was all on Kellogg to show that such a constant relation should be expected The total neglect of this basic assumption is a great weakness in the book, and should be a challenge to the authors for further work.

By no means do I share the belief that the only valid and worthwhile explanations in psychology are those phrased in physiological terms; but in this particular case, this study clearly seems to require for its completion a comparative neurological and physiological study of chimpanzees and human infants to find why the chimpanzee's tempo of psychological development compares so favorably at first with that of humans As a groundwork for such further studies this book has value, but until such further work is done, this study has interest only as simple descriptive material of completely uncertain theoretical significance.

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